Geotechnical Evaluation WA FLAP JEFFER 150009(1) Undi Road Bypass Improvements

Forks, Washington

May 5, 2022

Prepared for

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1 INTRODUCTION

As subconsultant to David Evans and Associates, Inc. (DEA), GRI completed a geotechnical and pavement investigation for the WA JEFFERSON 15009(1) Undi Road Bypass Improvement project located approximately five miles south of Forks, Washington, in Clallam and Jefferson Counties. Project team members include the Western Federal Lands Highway Division (WFLHD), Clallam County, Jefferson County, DEA, and GRI. Our work included a geologic reconnaissance; hand-augers; Kessler dynamic cone penetration tests; test pit excavations; geotechnical and pavement engineering analyses; and preparation of this report. This work follows up on the February 2021 report prepared by DEA titled, "Undi Road Bypass Improvements Final Scoping Design Report" and included geotechnical explorations.

2 PROJECT DESCRIPTION

The project area is located approximately 5 miles south of Forks, Washington, in Clallam and Jefferson counties. Undi Road is a about 1½ lanes wide and is surfaced with gravel which provides access to the Olympic National Forest and Bogachiel River Trail as well as several local residences. Between 2015 and 2016, a landslide occurred along Undi Road, resulting from high flows in the Bogachiel River, cutting and eroding the toe of the larger landslide feature located on the north side of the river. In 2016, a portion of the road through the landslide area was assessed to be unstable and an alternative route (i.e., the Undi Road Bypass) around the landslide area was designed and constructed by Jefferson County in order to maintain access to the Olympic National Forest and local residences. After construction of the Undi Bypass Road, Clallam and Jefferson counties identified three sites (designated Site 1, Site 2, and Site 3) along the Undi Road Bypass in need of further improvements. The general locations of the three sites and three pullouts site improvements are shown on Figure 2-1 and discussed below.

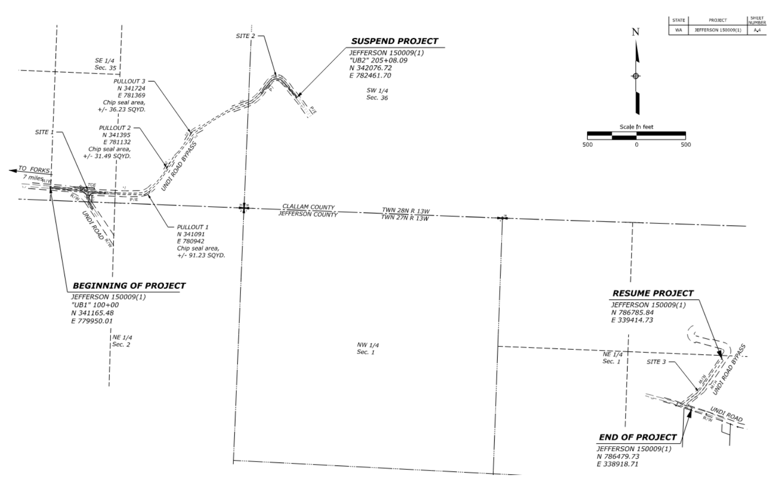

Figure: 2-1 – OVERVIEW OF THE SITE IMPROVEMENTS ON THE UNDI ROAD BYPASS

2.1 Site 1 (Jefferson County and Clallam County)

Proposed improvements at Site 1 will include reconfiguring the western intersection of Undi Road and Undi Road Bypass to make it clear that the primary route is the Undi Road Bypass. The work is expected to include signing, realignment, and a chip seal treatment of the primary route, the Undi Road Bypass.

2.2 Site 2 (Clallam County)

Proposed improvements at Site 2 will include the realignment of the sharp curve at the top of the first hill (mile point [MP] 0.47) to address limited sight distance and mobility configurations for longer vehicles such as logging trucks and horse trailers. We understand current plans call for widening the inside of the curve by approximately 15 feet to accommodate 10 feet of additional road surfacing and a 5-foot-wide ditch. Several feet of embankment may be needed to backfill the existing ditch line on the inside edge of the curve. Significant excavations will be made on the inside of the curve beyond the existing ditch line. This site will also receive a a chip seal.

2.3 Site 3 (Jefferson County)

Proposed improvements at Site 3 will include improving the eastern intersection of Undi Road and the Undi Road Bypass with signage and surfacing with a chip seal.

2.4 Other Improvements between Sites 1 and 2

In addition to the improvements listed above for the three sites, we also evaluated adding three truck pullouts at the locations shown on Figure 2-1 and chip seal to the roadway between Sites 1 and 2.

2.5 Geologic Setting

According to geologic mapping prepared by Gerstel and Lingley (2000), near-surface materials along the Undi Road bypass project consist of pre-Wisconsinan undifferentiated alpine glacial drift deposited from 200,000 years to 750,000 years ago. The alpine glacial drift includes outwash, till, and lacustrine deposits. Gerstel and Lingley identified alluvium adjacent to the Bogachiel River and near Site 3. The glacial drift and alluvium are likely underlain by marine sedimentary rocks consisting of sandstone, siltstone, and shale.

Gerstel (1999) identified several large landslide complexes in the project area, including an approximately 375-acre landslide that spans approximately 7,000 feet along the Bogachiel River, including the locations of Sites 1 and 3, and the 2015/2016 landslide along Undi Road that necessitated the construction of the bypass. The landslide is mapped just west of Site 2; however, a landslide scarp and colluvium observed during the geologic reconnaissance and field exploration program indicate that the landslide may extend to Site 2. The approximate 375-acre landslide, which is identified as #202, is shown below on Figure 2-2.

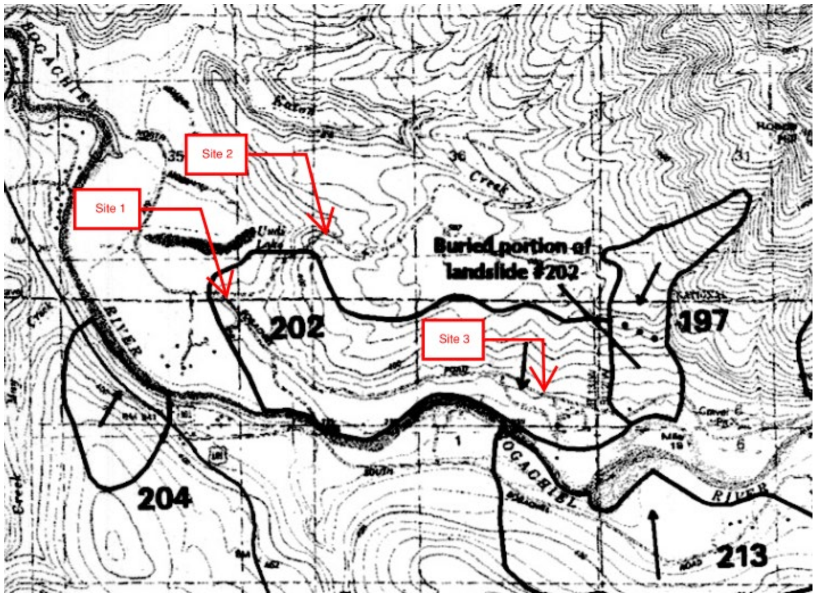

Figure: 2-2 – OVERVIEW OF THE EXISTING LANDSLIDE WITHIN THE PROJECT AREA (FROM GERSTEL, 1999)

3 FIELD INVESTIGATIONS AND LABORATORY TESTING

3.1 Site Conditions

Site 1 is located at the western intersection of the original Undi Road and the Undi Road Bypass and is located approximately 2 miles southeast of US Highway 101. The Undi Road Bypass is about 1½ lanes wide and is surfaced with gravel, which continues for the entire alignment.

Grades along the Undi Road Bypass between Sites 1 and 2 generally increase to the west from about elevation 242 feet at Site 1 to about elevation 464 feet at Site 2. Grades to the northwest along this stretch of the Undi Road Bypass drop steeply down towards Undi Lake. During the geotechnical and pavement investigation, GRI evaluated the conditions of the roadway surface in this area and did not observe surficial indications of subgrade or road base failures.

At Site 2, the Undi Road Bypass makes a greater than 90° turn from the northeast to the southeast direction for travelers headed eastbound. Site 2 is located between DEA project Station 200+00 and 205+08.09 In this area, the existing roadway grades increase from about elevation 464 feet at Station 200+00 to elevation 491 feet at Station 202+00 near the apex of the sharp turn. Roadway grades further increase from the apex of the curve to about elevation 530 feet at Station 205+08.09. Site grades increase to the south of Undi Road in the Site 2 area. A near-vertical landslide scarp and bowed trees are present above and to the southeast of Undi Road between about Station 200+00 and 201+25. After Station 201+25, the grades above Undi Road are relatively uniform and inclined at about 1½H:1V (Horizontal to Vertical). The top of the slope above the roadway at Site 2 is at about an elevation of 532 feet. Relatively flat ground is located beyond the top of the slope.

Topographic mapping of the area to the north of Undi Road was not available. Site grades decrease to the northwest of Undi Road between Station 200+00 and 202+00 generally drop steeply from the edge of the roadway towards Bear Creek and Eaton Creek. Site grades to the northeast of Undi Road between Station 202+00 and 205+08.09 include typically a wider shoulder area prior to sloping towards Bear Creek and Eaton Creek or increasing site grades.

Site 3 is the easterly intersection of the original Undi Road alignment and the Undi Road Bypass on the east side of the recent 2015 and 2016 landslide. Jefferson County designed the bypass road with a 4-inch crushed-surfacing base course over 20-inch Select Borrow material for the base. Based on discussions with the project team, we understand that near the T-Intersection at Site 3, the constructions crew encountered blue-gray clay. This soil is very weak and provides poor support for construction equipment. The contractor placed logs perpendicular to the centerline for a working platform (known as a corduroy road) to support construction equipment and embankment fills. The logs were left in place and incorporated into the embankment.

3.2 Subsurface Explorations and Conditions

3.2.1 General

The subsurface materials and conditions at the site were investigated between October 27, 2021, and October 29, 2021. The field exploration program including three test pits at Site 2, designated TP-1 through TP-3; 14 hand-auger explorations, designated HA-1, HA-2A, HA-2B, and HA-3 through HA-13, spanning between Sites 1 and 2 and at Site 3; and 13 Kessler Dynamic Cone Penetration (DCP) tests adjacent to the hand-auger borings. The approximate location of the explorations completed for this investigation are shown on Figure 3-1. A discussion of the field exploration and laboratory testing programs completed for this investigation is provided in Appendix A. Logs of the test pits are provided on Figures 1A and 2A and logs of the hand-auger borings are provided on Figures 3A through 9A. The terms and symbols used to describe the soils encountered in the test pits and hand-auger borings are provided in Table 1A.

3.2.2 Test Pits

The subsurface exploration program included advancing three test pit explorations, designated TP-1, TP-2, and TP-3, into the hillside and above the existing roadway ditch, at about Station 201+20, 201+90, and 202+50, respectively. The test pits were excavated by Howard's Construction and Excavating of Olympia, Washington, under subcontract to GRI.

TEST PIT COMPLETED BY GRI (OCTOBER 28, 2021)

HAND-AUGER/KESSLER DCP EXPLORATIONS COMPLETED BY GRI (OCTOBER 27 TO 29, 2021)

GRI

DAVID EVANS AND ASSOCIATES, INC.
WA JEFFERSON 150009 (1), UNDI
ROAD DBYPASS IMPROVEMENTS

SITE PLAN

MAY 2022 | JOB NO. W1285-TO 2 | FIG. 3-1

The test pits exposed approximately 5 feet, 1.5 feet, and 5 feet of hillside material in test pits TP-1, TP-2, and TP-3, respectively.

A 4-inch to 6-inch-thickness of heavily rooted/forest duff zone was encountered on the hillside slope in the test pits completed for this study. In test pit TP-1, material exposed in the test pit consists of colluvium (i.e., landslide debris). The colluvium encountered to a depth of 2 feet consists of clayey silt with some fine- to coarse-grained sand. Trace gravel and cobbles and scattered roots and organics were observed in the upper portion of the colluvium. The colluvium below 2 feet consists of loose to medium-dense, sandy gravel or sand with some gravel and some silt. In test pits TP-2 and TP-3, glacial outwash consisting of medium-dense to dense sandy gravel with some silt was encountered below the heavily-rooted zone. Cobbles were encountered within the glacial outwash.

3.2.3 Hand-Auger Explorations

A GRI team member performed the hand-auger explorations located within and outside the existing roadway prism. We observed aggregate thickness ranging from 5 inches to over 24 inches both within and outside the roadway prism. The subgrade soils at the hand-auger exploration locations generally range from sand to silt with some sand and silty sand or sandy silt. We also encountered gravel and cobbles in 10 of the 13 explorations.

3.2.4 Groundwater

The test pit explorations were completed on October 28, 2021, during a period of heavy rainfall. Slight groundwater seepage was encountered about 2 feet above the existing ditch grades in test pit TP-1 and heavy groundwater seepage was encountered about 1 foot above the existing ditch grades in test pit TP-2. Groundwater was not encountered within the depths explored in any of the remaining explorations completed for this investigation.

3.3 Kessler Dynamic Cone Penetration Testing

We performed 13 Kessler DCP tests, designated KDCP-1 through KDCP-13, adjacent to hand-auger borings HA-1 to HA-13. The results of the DCP tests are shown on Figures 10A through 22A and summarized in Table 1A in Appendix A.

3.4 Laboratory Testing

GRI performed laboratory testing to note the physical characteristics and modified the field classifications of the collected soil samples where necessary. The laboratory testing program included determinations of natural moisture contents and grain-size analysis on selected samples obtained from the explorations. The results of the laboratory testing are included in Appendix A.

4 GEOTECHNICAL CONSIDERAITIONS

4.1 General

As discussed above, a near-vertical scarp and bowed trees indicative of a landslide were observed during the site investigation at Site 2 on the southeastern side of the Undi Road Bypass between Station 200+00 and Station 201+25. In test pit TP-1, advanced within this area, landslide debris was encountered. In test pits TP-2 and TP-3, glacial outwash consisting of medium-dense to dense, sandy gravel with some silt and cobbles was encountered. Heavy groundwater seepage was observed while advancing test pit TP-2 starting about 1 foot above the existing roadway grades.

4.2 Site Preparation

The hillside at Site 2 is mantled with a layer of duff/organics with an average thickness of about 6 inches. The duff soils are generally fine grained and contain a large percentage of organic matter. It should be anticipated deeper stripping and grubbing will be necessary where trees and shrubs are present. The stripped materials are not suitable for use as compacted structural fill and should be disposed of at an approved off-site location.

Materials observed in the hand-auger borings advanced along the roadway alignment typically consist of silty sand, sandy silt, or silt overlain by a 5- to 10-inch-thick crushed rock pavement section.

Following stripping or excavation to subgrade level, the resulting subgrade within the area of the improvements should be evaluated by qualified geotechnical engineering staff and soft soils or areas of unsuitable material should be overexcavated and replaced with Select Borrow meeting the requirements of Section 704.07 of FHWA *Standard Specifications for Construction of Roads and Bridges on Federal Highway Projects* (FP-14). To minimize disturbance to fine-grained subgrade soils, we recommend working from the existing roadway surface and the use of hydraulic excavators equipped with smooth cutting edges for site stripping and subgrade preparation. During and following stripping and excavation, the contractor must use care to protect the subgrade from disturbance by construction traffic.

Material generated during stripping, grubbing, and grading activities needed to establish final site grades should either be removed from the site immediately after removal or stockpiled a minimum of 15 feet beyond the top of the planned 1½H:1V permanent slope at Site 2. Stockpiling material along the roadway alignment between Sites 1 and 2 should also be avoided.

4.3 Structural Fill

We understand that fills needed to establish final grades at Site 2 will be limited to placement up to 2 feet of fill in the existing roadway ditch line. We recommend general earthwork, including construction of new fills, be completed in accordance with the Division 200 of the FHWA FP-14.

In our opinion, any material free of organics or other deleterious materials and approved by the geotechnical engineer are suitable for use as embankment fill material. We anticipate that the material excavated from the hillside at Site 2 will consist primarily of sandy gravel with some silt. Layers of more fine-grained materials were observed within the colluvium encountered in test pit TP-1. Cobbles and boulders were encountered within the sandy gravel unit. As a result of the oversized materials and relatively high fines content, the excavated material classifies as Unclassified Material in Section 704.06 of FHWA FP-14. Oversized boulders should be removed or crushed in accordance with Section 204.10 of FHWA FP-14 if incorporated into the structural fill.

Silty soils are moisture sensitive and can be placed and adequately compacted during the dry summer months when the moisture content can be maintained near optimum. For construction during the wet winter and spring months, embankment fills should consist of relatively clean, well-graded, crushed rock with less than 8% passing the No. 200 sieve (washed analysis). Select Granular Backfill meeting the requirements of Section 704.08 of the FHWA FP-14 is a suitable wet weather material. All new embankment fill should be installed as structural fill compacted to at least 95% of the maximum dry density as determined by American Association of State Highway and Transportation Officials standard method T99 (AASHTO T99). The moisture content of soils at the time of compaction should be controlled to within 2% of optimum. Some aeration and drying of the on-site soils may be required to meet the recommended compaction criteria.

4.4 Cut Slope and Ditch Recommendations

In our opinion, the roadway widening at Site 2 can be accommodated by cutting into the existing hillside slope at a maximum inclination of 1½H:1V. South of Station 201+25 and within the zone of the landslide area, cross-sections developed by DEA indicate that significant cuts into the hillside may not be necessary to accommodate the widened roadway. However, to reduce the risk of potential slope movement impacting the roadway in the future, we recommend that the slope in this area be graded to 1½H:1V to remove the landslide debris. This additional grading is recommended when the catchpoint of the steeper slope is located within 50 feet of the centerline of the proposed roadway ditch. An experienced geotechnical professional should be present to document removal of the landslide debris. The geotechnical professional should also evaluate the stability of boulders or cobbles on the finished slopes and the necessity of removal. To minimize erosion and to allow development of permanent vegetation, the final excavation slopes should be protected with a temporary erosion control blanket.

Heavy groundwater seepage was observed during the excavation of test pit TP-2. To collect this groundwater seepage, we recommend installing a pavement edge drain on the inside roadway ditch between Stations 201+15 and 202+40. The pavement edge drain should consist of a Standard Underdrain and be constructed in accordance with Section 605 of FHWA *Standard Specifications for Construction of Roads and Bridges on Federal Highway Projects* (FP-14). The invert of the pavement edge drainpipe should be at least 3 feet below the base of the roadway ditch and daylight to the roadway located downgradient of Site 2.

We anticipate that some groundwater seepage may occur within the slope above the roadway ditch during periods of heavy rainfall. We recommend that the slopes be periodically monitored during periods of heavy rainfall to evaluate seeps, their potential impacts, and to develop potential mitigation measures that may be needed to minimize potential erosion.

To minimize the risk of inducing movement, we recommend that the permanent excavation slopes be made by working from the top of the slope and working down the slope as much as possible. Construction of the proposed improvements, including the pavement edge drains, should occur during the dry-summer and early-fall months (i.e., July to about mid-October) to minimize construction dewatering requirements, handling of groundwater, and potential slope stability considerations. We anticipate that the excavations for the roadway cuts can be made using a large hydraulic excavator equipped with rock teeth.

4.5 Deep Patch Recommendations Between Sites 1 and Site 2

As discussed previously and shown on Figure 2-2, a historical landslide is present between Sites 1 and 2. GRI completed a limited reconnaissance of the conditions of the road surfacing along this portion of the Undi Road Bypass and observed no obvious indications of subgrade or road base failures. Based on these observations, it is our opinion that deep patch pavement repairs are not warranted at this time.

Slope stability analysis for the slope located downhill of Undi Road between Sites 1 and 2 is beyond the scope of our geotechnical investigation. However, in our opinion, the placement of large quantities of structural fill in this area could result in slope instability. In this regard, we recommend that changes to the existing roadway grades in this area be limited to less than about 1 foot.

5 PAVEMENT DESIGN APPROACH

GRI accomplished the pavement design analysis in general accordance with the guidelines given in the 1993 American Association of State Highway and Transportation Officials (AASHTO) *Guide for Design of Pavement Structures* (AASHTO Guide) and the Federal

Highway Administration (FHWA) Project Development Design Manual. Details of our field explorations and laboratory testing program are provided in Appendix A and a summary of our pavement-design analysis is provided in Appendix B.

6 PAVEMENT DESIGN ANALYSIS

Our pavement-design analysis was conducted in order to estimate the structural requirements to meet an approximate future traffic loading based on the existing roadway structural capacity and subgrade support conditions.

6.1 Design Subgrade Resilient Modulus

We used the DCP test data summarized in Appendix A to estimate the design subgrade resilient modulus value within the project limits. The DCP test results are used to estimate the California bearing ratio, which is correlated to the subgrade resilient modulus based on the relationship developed by Chen et al. (1999). We estimated a design subgrade resilient modulus value of 6,100 pounds per square inch (psi) based on the 2.3-percentile value divided by 0.70. This procedure follows the statistical-reliability assumptions in the AASHTO Guide design procedure, which is based on using the average subgrade modulus as the design value provided the coefficient of variation (CoV) does not exceed 15%.

6.2 Traffic-Loading Analysis

The traffic-loading approximation for the Undi Road Bypass provided in the Federal Lands Access Program (FLAP) grant application did not provide enough details to estimate the cumulative 18-kip Equivalent Single-Axle Load (ESAL) repetitions (traffic loading). Specifically, it did not include a distribution of trucks by the FHWA vehicle classifications, and at the time of this report that information was still unavailable. Previously collected annual daily traffic within the vicinity of Undi Road ranges from 50 to 103, with the known mixture of vehicles consisting of passenger cars and trucks, recreations vehicles, and logging trucks. For our analysis, we a traffic loading of 50,000 ESALs, which is the minimum value recommended in the AASHTO Guide for low-volume roads.

6.3 Pavement and Full-Depth Repair Design Analysis

For roadways surfaced with chip seals, the chip seal layer provides very little to no structural value; therefore, our analysis was based on the aggregate thickness required to support the traffic loading. We used a maximum rutting threshold in our design evaluation of 2 inches, which we assume is a practical maximum for a low-volume, low-speed, chip seal-surfaced road and this also represents the end of the road’s useful life. The pavement design analysis was accomplished in general accordance with the AASHTO Guide design for low-volume roads using the parameters shown in Figure 1B in Appendix B.

7 PAVEMENT DESIGN RECOMMENDATIONS

Our pavement-design recommendations are given below.

7.1 Chip Seal of Undi Road and Pullouts

Existing Undi Road Alignment

- Type 2B Double Course Chip Seal
  - FP-14 Section 407
- Roadway Reconditioning
  - FP-14 Section 303.06

Pullouts and New Undi Road Alignment at Site 1

- Type 2B Double Course Chip Seal
  - FP-14 Section 407
- 12-inch-thick Minor Crushed Aggregate
  - FP-14 Section 302 Method 2
- Nonwoven Geotextile Fabric
  - FP-14 Section 207, Class 1 Type B

7.2 Full-Depth Repair with Reconstruction

During our initial field investigation, we did not identify areas with distresses that would indicate the potential need for full-depth repair. Since there may be time delay between design and construction, for estimating purposes, we recommend assuming up to 1% of the roadway area between Sites 1 and 2 may require full-depth repair. We recommend using the following section for full-depth repair.

Full-Depth Repair

- 12-inch-thick Minor Crushed Aggregate
  - FP-14 Section 302 Method 2
- Nonwoven Geotextile Fabric
  - FP-14 Section 207, Class 1 Type B

8 RECOMMENDATIONS FOR MATERIALS AND CONSTRUCTION

8.1 Standard Specifications

Construction materials and procedures should comply with the applicable sections of FHWA FP-14, *Standard Specifications for Construction of Road and Bridges on Federal Highway Projects*, with the modifications or supplements given below.

Table 8-1: RECOMMENDED MATERIAL SPECIFICATIONS

Materials/Activity	FHWA FP-14	Specification Comments
Roadway Reconditioning	Section 303	Recondition the existing aggregate roadway according to Section 303.06
Subgrade Geosynthetics	Section 207	Provide a Class 1 Type B nonwoven geotextile according to Table 714-1.
Minor Crushed Aggregate	Section 302	Provide crushed aggregate that meets Section 703.06 requirements.
Chip Seal	Section 407	Place a Type 2B double course chip seal. Use a high float emulsion.

8.2 Pavement Construction Considerations

The pavement sections provided above assume pavement construction will be accomplished during warm, dry conditions and all workmanship and materials will conform to the applicable specifications. In areas requiring full-depth repair during periods of wet weather or when wet-ground conditions exist, it may be necessary to increase the thickness of the AB in order to support construction equipment and protect the potentially moisture-sensitive subgrade soils from disturbance.

Adequate drainage is critical for a well-performing pavement. The design team should verify there is positive drainage in order to move water away from the AB layer. Failure to provide adequate drainage may result in the entrapment of water in the AB layer, which may lead to a reduced pavement life.

8.3 Aggregate Surfacing

After reconditioning the existing aggregate roadway, if non-construction-related traffic is permitted on the road before the chip seal construction is complete, additional grading may be necessary to surface irregulates such as rutting or wash boarding.

8.4 Maintenance Considerations

We designed the pavement structure for an approximated traffic loading, but routine maintenance will be necessary to correct potential areas of localized distress or repair surface defects. Typically, a new chip-seal application will be necessary every five years to seven years. We also recommend the Counties apply a second double course chip seal within the first three years following initial construction.

9 DESIGN REVIEW AND CONSTRUCTION SERVICES

We welcome the opportunity to review and discuss construction plans and specifications for this project as they are being developed. In addition, GRI should be retained to review all geotechnical-related portions of the plans and specifications to evaluate whether they are in conformance with the recommendations provided in our report and to observe compliance with the intent of our recommendations. Our construction-phase services will allow for timely design changes if site conditions are encountered that are different from those described in our report. If we do not have the opportunity to confirm our interpretations, assumptions, and analyses during construction, we cannot be responsible for the application of our recommendations to subsurface conditions different from those described in this report.

10 LIMITATIONS

This report has been prepared to aid the project team in the design of this project. The scope is limited to the specific project and location described in this report, and our description of the project represents our understanding of the significant aspects of the project relevant to design and construction on Undi Road. In the event that any changes in the design and location of the project elements as outlined in this report are planned, we should be given the opportunity to review the changes and modify or reaffirm the conclusions and recommendations of this report in writing.

The conclusions and recommendations in this report are based on the data obtained from the subsurface explorations at the locations shown on Figure 3-1 and other sources of information discussed in this report. In the performance of subsurface investigations, specific information is obtained at specific locations at specific times. However, it is acknowledged that variations in subsurface conditions may exist between exploration locations. This report does not reflect variations that may occur between these explorations. The nature and extent of variation may not become evident until construction. If, during construction, subsurface conditions differ from those encountered in the explorations, we should be advised at once so we can observe and review these conditions and reconsider our recommendations where necessary.

Submitted for GRI,

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(Issued 06/11/2020) Renews 05/2023

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This document has been submitted electronically.

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GRI

APPENDIX A

Field Explorations and Laboratory Testing

APPENDIX A
FIELD EXPLORATIONS AND LABORATORY TESTING

A.1 FIELD EXPLORATIONS

A.1.1 General

Subsurface materials and conditions along the Undi Road Bypass were investigated by GRI between October 27 and 29, 2021, with three test pit explorations, designated TP-1 through TP-3; 14 hand-auger borings, designated HA-1, HA-2A, HA-2B, and HA-3 through HA-13; and 13 Kessler dynamic cone penetrometer (DCP) probes, designated KDCP-1 through KDCP-13. The approximate locations of the subsurface explorations are shown on Figure 3-1. The field-exploration and laboratory-testing programs completed for this project are described below.

A.1.2 Test Pit Explorations

Test pits TP-1 through TP-3 were advanced into the hillside above the roadside ditch using a tracked excavator supplied and operated by Howard's Construction and Excavating of Olympia, Washington, under subcontract to GRI. The test pits exposed soil located between 1½ feet and 5 feet above the top of the ditch.

A GRI representative directed the explorations and maintained a detailed log of the materials and conditions disclosed during the work. The materials exposed in the excavations were examined in the field and selected portions of the exposed materials were saved. The samples collected in the explorations were returned to our laboratory for further examination and testing. After completion of digging and sampling, the excavation spoils were placed back into the test pit excavation in and compacted by tamping with the back of the backhoe bucket and the ground surface was covered with straw.

Logs of the test pit explorations are provided on Figures 1A and 2A. The logs present a descriptive summary of the various types of materials encountered in the test pits and note the approximate depth where the materials and/or characteristics of the materials change. To the right of the descriptive summary, the numbers and types of samples taken, along with the natural moisture contents and percentage of material passing the No. 200 sieve, are shown graphically. The terms used to describe the soils are defined in Table 1A and the attached legend.

A.1.3 Hand-Augered Boring

Borings HA-1, HA-2A, HA-2B, and HA-3 through HA-13 were advanced to depths of between about 1.7 feet and about 2.3 feet using a hand-operated auger. The borings were completed by a member of GRI's staff, who maintained a log of the materials and conditions disclosed during the course of the work. Disturbed samples of the soil cuttings were obtained at varying depths, classified, placed in plastic bags, and returned to our laboratory for further examination. Logs of the hand-auger borings are provided on Figures 3A through 9A. These logs present a descriptive summary of the various types of materials encountered in the borings and note the depths at which the materials and/or characteristics of the materials change. To the right of the descriptive summary, the numbers and types of samples are indicated. Farther to the right, natural moisture contents and fines contents are displayed. The terms and symbols used to describe the soils encountered in the boring are defined in Table 1A and the attached legend.

A.1.4 Dynamic Cone Penetration Tests

We completed DCP testing in general accordance with ASTM International (ASTM) D6951 to a depth of about 40 inches below ground surface using a Kessler dynamic cone penetrometer manufactured by KSE Testing Equipment. We completed the testing at the hand-auger locations by driving a ⅝-inch-diameter steel rod with a cone tip into the soil using a 17.6-pound sliding hammer dropped from a fixed height of 22.6 inches. We recorded the number of hammer drops or blows required to advance the cone tip at approximately one-inch increments. We used the DCP blow counts to estimate a California bearing ratio (CBR) and resilient modulus value for the in-situ subgrade soil at each test location. The Kessler DCP results are shown on Figures 10A and 22A. A summary of the equivalent subgrade modulus values approximated from the results are provided in Table 1A below.

Table 1A: DCP SUMMARY TABLE

DCP Test Number	Estimated Subgrade Modulus, psi	Approximate Location
1	10,010	Site 1
2	6,930	Site 1
3	13,370	Site 1-2
4	8,310	Site 1-2
5	5,830	Site 1-2
6	7,220	Site 1-2
7	8,800	Site 2
8	4,400	Site 2
9	8,130	Site 2
10	5,240	Site 2
11	6,670	Site 2
12	5,410	Site 3
13	4,220	Site 3
Average Subgrade Modulus, psi	7,272	
Standard Deviation	2,526	
Coefficient of Variation	34.7	
Design Subgrade Modulus (2.3-percentile value divided by 0.70), psi	**6,100**	

A.2 LABORATORY TESTING

A.2.1 General

We brought all samples obtained from the field-exploration program to our laboratory for examination and testing. We noted the physical characteristics and modified the field classifications where necessary. The laboratory-testing program included determinations of natural moisture contents and performing grain size testing on selected samples.

A.2.2 Natural Moisture Content

We determined the natural moisture content in conformance with ASTM International D2216. The results are summarized in Table 3A.

A.2.3 Grain-Size Analysis

Washed-sieve analyses were performed on selected samples to determine the percentage of material passing the No. 200 sieve. The test is performed by taking a sample of known dry weight and washing it over a No. 200 sieve. The material retained on the sieve is oven-dried and weighed, and the percentage of material passing the No. 200 sieve is calculated. The test results are provided on Figures 1A through 9A and in Table 3A.

Additionally, a sample obtained from test pit TP-3 received a complete mechanical-sieve analysis in substantial conformance with ASTM D6913. The test is performed by taking a sample of known dry weight and washing it over a No. 200 sieve. The material retained on the sieve is oven-dried and weighed, and the percentage of material passing the No. 200 sieve is calculated. The soil retained on the No. 200 sieve is then screened through a series of sieves of various sizes using a sieve shaker. The weight of each sieve is measured prior to and after the test. The weight of the soil retained on each sieve is recorded and expressed as a percentage of the total sample weight. A grain-size distribution curve for this sample is provided on Figure 23A.

Table 2A

GUIDELINES FOR CLASSIFICATION OF SOIL

Description of Relative Density for Granular Soil

Relative Density	Standard Penetration Resistance (N-values) blows/foot
Very Loose	0 - 4
Loose	4 - 10
Medium Dense	10 - 30
Dense	30 - 50
Very Dense	over 50

Description of Consistency for Fine-Grained (Cohesive) Soils

Consistency	Standard Penetration Resistance (N-values) blows/foot	Torvane or Undrained Shear Strength, tsf
Very Soft	0 - 2	less than 0.125
Soft	2 - 4	0.125 - 0.25
Medium Stiff	4 - 8	0.25 - 0.50
Stiff	8 - 15	0.50 - 1.0
Very Stiff	15 - 30	1.0 - 2.0
Hard	over 30	over 2.0

Grain-Size Classification

Boulders:
- >12 in.

Cobbles:
- 3-12 in.

Gravel:
- ¼ - ¾ in. (fine)
- ¾ - 3 in. (coarse)

Sand:
- No. 200 - No. 40 sieve (fine)
- No. 40 - No. 10 sieve (medium)
- No. 10 - No. 4 sieve (coarse)

Silt/Clay:
- Pass No. 200 sieve

Modifier for Subclassification

Adjective	Primary Constituent SAND or GRAVEL	Primary Constituent SILT or CLAY
	Percentage of Other Material (By Weight)	
trace:	5 - 15 (sand, gravel)	5 - 15 (sand, gravel)
some:	15 - 30 (sand, gravel)	15 - 30 (sand, gravel)
sandy, gravelly:	30 - 50 (sand, gravel)	30 - 50 (sand, gravel)
trace:	<5 (silt, clay)	*Relationship of clay and silt determined by plasticity index test*
some:	5 - 12 (silt, clay)	
silty, clayey:	12 - 50 (silt, clay)	

Table 3A

SUMMARY OF LABORATORY RESULTS

Sample Information						Atterberg Limits			
Location	Sample	Depth, ft	Elevation, ft	Moisture Content, %	Dry Unit Weight, pcf	Liquid Limit, %	Plasticity Index, %	Fines Content, %	Soil Type
HA-1	S-1	0.8	--	12	--	--	--	--	SAND
	S-2	1.3	--	10	--	--	--	--	SAND
	S-3	1.7	--	11	--	--	--	--	SAND
HA-2A	S-1	0.8	--	30	--	--	--	--	Silty SAND
	S-2	1.2	--	38	--	--	--	30	Silty SAND
	S-3	1.7	--	42	--	--	--	--	Silty SAND
HA-2B	S-1	0.2	--	15	--	--	--	--	GRAVEL
	S-2	0.5	--	16	--	--	--	--	SAND
	S-3	1.3	--	17	--	--	--	--	SAND
HA-3	S-1	0.8	--	8	--	--	--	--	Sandy GRAVEL
	S-2	1.5	--	9	--	--	--	--	Sandy GRAVEL
HA-4	S-1	0.5	--	17	--	--	--	--	SILT
	S-2	1.2	--	22	--	--	--	--	SILT
	S-3	1.8	--	24	--	--	--	--	SILT
HA-5	S-1	0.7	--	14	--	--	--	16	Silty SAND
	S-2	1.5	--	19	--	--	--	--	Silty SAND
HA-6	S-1	0.5	--	14	--	--	--	--	Sandy SILT
	S-2	1.2	--	19	--	--	--	--	Sandy SILT
HA-7	S-1	0.7	--	11	--	--	--	--	SAND
HA-8	S-1	1.3	--	11	--	--	--	--	FILL
	S-2	1.8	--	12	--	--	--	--	FILL
HA-9	S-1	0.8	--	9	--	--	--	--	Sandy GRAVEL
	S-2	1.7	--	25	--	--	--	--	Sandy GRAVEL
HA-10	S-1	0.5	--	20	--	--	--	--	Silty SAND
	S-2	1.8	--	34	--	--	--	--	Sandy SILT
HA-11	S-1	0.5	--	18	--	--	--	--	Sandy SILT
	S-2	1.3	--	22	--	--	--	--	Silty SAND
HA-12	S-1	0.7	--	50	--	--	--	--	SILT
	S-2	1.3	--	33	--	--	--	--	SILT
HA-13	S-1	0.8	--	40	--	--	--	--	SILT
	S-2	1.7	--	48	--	--	--	--	SILT
TP-1	S-1	1.0	--	41	--	--	--	56	Clayey SILT
	S-3	2.0	--	29	--	--	--	--	Sandy GRAVEL
TP-3	S-1	2.0	--	15	--	--	--	6	Sandy GRAVEL

BORING AND TEST PIT LOG LEGEND

SOIL SYMBOLS

Symbol	Typical Description
	LANDSCAPE MATERIALS
	FILL
	GRAVEL; clean to some silt, clay, and sand
	Sandy GRAVEL; clean to some silt and clay
	Silty GRAVEL; up to some clay and sand
	Clayey GRAVEL; up to some silt and sand
	SAND; clean to some silt, clay, and gravel
	Gravelly SAND; clean to some silt and clay
	Silty SAND; up to some clay and gravel
	Clayey SAND; up to some silt and gravel
	SILT; up to some clay, sand, and gravel
	Gravelly SILT; up to some clay and sand
	Sandy SILT; up to some clay and gravel
	Clayey SILT; up to some sand and gravel
	CLAY; up to some silt, sand, and gravel
	Gravelly CLAY; up to some silt and sand
	Sandy CLAY; up to some silt and gravel
	Silty CLAY; up to some sand and gravel
	PEAT

BEDROCK SYMBOLS

Symbol	Typical Description
	BASALT
	MUDSTONE
	SILTSTONE
	SANDSTONE

SURFACE MATERIAL SYMBOLS

Symbol	Typical Description
	Asphalt concrete PAVEMENT
	Portland cement concrete PAVEMENT
	Crushed rock BASE COURSE

SAMPLER SYMBOLS

Symbol	Sampler Description
	2.0 in. O.D. split-spoon sampler and Standard Penetration Test with recovery (ASTM D1586)
	Shelby tube sampler with recovery (ASTM D1587)
	3.0 in. O.D. split-spoon sampler with recovery (ASTM D3550)
	Grab Sample
	Rock core sample interval
	Sonic core sample interval
	Push probe sample interval

INSTALLATION SYMBOLS

Symbol	Symbol Description
	Flush-mount monument set in concrete
	Concrete, well casing shown where applicable
	Bentonite seal, well casing shown if applicable
	Filter pack, machine-slotted well casing shown where applicable
	Grout, vibrating-wire transducer cable shown where applicable
P	Vibrating-wire pressure transducer
	1-in.-diameter solid PVC
	1-in.-diameter hand-slotted PVC
	Grout, inclinometer casing shown where applicable

FIELD MEASUREMENTS

Symbol	Typical Description
∇	Groundwater level during drilling and date measured
▼	Groundwater level after drilling and date measured
	Rock/sonic core or push probe recovery (%)
	Rock quality designation (RQD, %)

DEPTH, FT	GRAPHIC LOG	CLASSIFICATION OF MATERIAL	ELEVATION, FT / DEPTH, FT	SAMPLE NO.	SAMPLE TYPE	● MOISTURE CONTENT, % □ FINES CONTENT, % ├─┤ LIQUID LIMIT, % / PLASTIC LIMIT, % (0 – 50 – 100)	COMMENTS AND ADDITIONAL TESTS

TP-1

Surface Elevation: Not Available

Depth, ft	Classification of Material	Elevation, ft / Depth, ft	Sample No.	Comments and Additional Tests
0–2.0	Clayey SILT, some fine-to coarse-grained sand, trace gravels and cobbles, brown with gray streaks, loose, scattered roots and organics, 6-inch-thick heavily rooted/forest duff zone at ground surface	2.0	S-1	Test pit excavated into existing hillside and 5 feet above existing roadway ditch.
2.0–2.5	Sandy GRAVEL, some silt, loose to medium dense, fine-to coarse-grained sand, rounded to subrounded gravel, contains cobbles and scattered roots	2.5	S-2	Moderate caving of sidewalls and slight groundwater seepage observed 2 feet above roadway ditch.
2.5–5.0	SAND, some silt, trace to some rounded gravel, medium dense	5.0		
	(10/28/2021)			

0 0.5 1.0

◆ TORVANE SHEAR STRENGTH, TSF

Logged By: G. Martin	**Excavated by:** Howard's Construction	**Equipment:** Track-Mounted Excavator
Date Started: 10/28/21	**GPS Coordinates:** 47.8846° N 124.332° W (WGS84)	**Note:** See Legend for Explanation of Symbols

TP-2

Surface Elevation: Not Available

Depth, ft	Classification of Material	Elevation, ft / Depth, ft	Sample No.	Comments and Additional Tests
0–1.5	Sandy GRAVEL, some silt, moist to wet, medium dense, fine-to coarse-grained sand, rounded to subrounded gravel, contains cobbles and boulders, 4-inch-thick heavily rooted/forest duff zone at ground surface	1.5	S-1	Test pit excavated into existing hillside and 1.5 feet above existing roadway ditch. Heavy groundwater seepage observed 1 foot above roadway ditch.
	(10/28/2021)			

0 0.5 1.0

◆ TORVANE SHEAR STRENGTH, TSF

Logged By: G. Martin	**Excavated by:** Howard's Construction	**Equipment:** Track-Mounted Excavator
Date Started: 10/28/21	**GPS Coordinates:** 47.8848° N 124.332° W (WGS84)	**Note:** See Legend for Explanation of Symbols

GRI TP LOG (GPS) - 2 PP GRI DATA TEMPLATE.GDT 5/4/22

GRI

TEST PITS

MAY 2022 JOB NO. W1285-TO2 FIG. 1A

DEPTH, FT	GRAPHIC LOG	CLASSIFICATION OF MATERIAL	ELEVATION, FT / DEPTH, FT	SAMPLE NO.	SAMPLE TYPE	● MOISTURE CONTENT, % ☐ FINES CONTENT, % ├─┤ LIQUID LIMIT, % PLASTIC LIMIT, % (0 – 50 – 100)	COMMENTS AND ADDITIONAL TESTS
TP-3		**Surface Elevation:** Not Available				0 – 50 – 100	
0–5		Sandy GRAVEL, some silt, moist to wet, medium dense, fine-to coarse-grained sand, rounded to subrounded gravel, contains cobbles and boulders, 6-inch-thick heavily rooted/forest duff zone at ground surface		S-1	☒	☐ ●	Test pit excavated into existing hillside and 5 feet above existing roadway ditch.
5		(10/28/2021)	5.0				
10							

0 – 0.5 – 1.0

◆ TORVANE SHEAR STRENGTH, TSF

Logged By: G. Martin **Excavated by:** Howard's Construction **Equipment:** Track-Mounted Excavator

Date Started: 10/28/21 **GPS Coordinates:** 47.8847° N 124.332° W (WGS84) **Note:** See Legend for Explanation of Symbols

DEPTH, FT	GRAPHIC LOG	CLASSIFICATION OF MATERIAL	ELEVATION, FT / DEPTH, FT	SAMPLE NO.	SAMPLE TYPE	● MOISTURE CONTENT, % □ FINES CONTENT, % ├─┤ LIQUID LIMIT, % PLASTIC LIMIT, % (0 50 100)	COMMENTS AND ADDITIONAL TESTS

HA-1 **Surface Elevation:** Not Available

SAND, some silt, trace subrounded gravel and cobbles, dark brown to brown, fine to medium grained
---some cobbles below 15 inches

2.2

(10/27/2021)

S-1
S-2
S-3

Depth scale: 5, 10

0 0.5 1.0
◆ TORVANE SHEAR STRENGTH, TSF

Logged By: A. Horst	**Excavated by:** GRI	**Equipment:** Hand Auger
Date Started: 10/27/21	**GPS Coordinates:** 47.8811° N 124.34° W (WGS84)	**Note:** See Legend for Explanation of Symbols

HA-2A **Surface Elevation:** Not Available

Silty SAND, dark brown, contains organics, fineto medium grained

1.8

SILT, some fine-grained sand, dark brown

2.3

(10/27/2021)

S-1
S-2
S-3

Depth scale: 5, 10

0 0.5 1.0
◆ TORVANE SHEAR STRENGTH, TSF

Logged By: A. Horst	**Excavated by:** GRI	**Equipment:** Hand Auger
Date Started: 10/27/21	**GPS Coordinates:** 47.8814° N 124.339° W (WGS84)	**Note:** See Legend for Explanation of Symbols

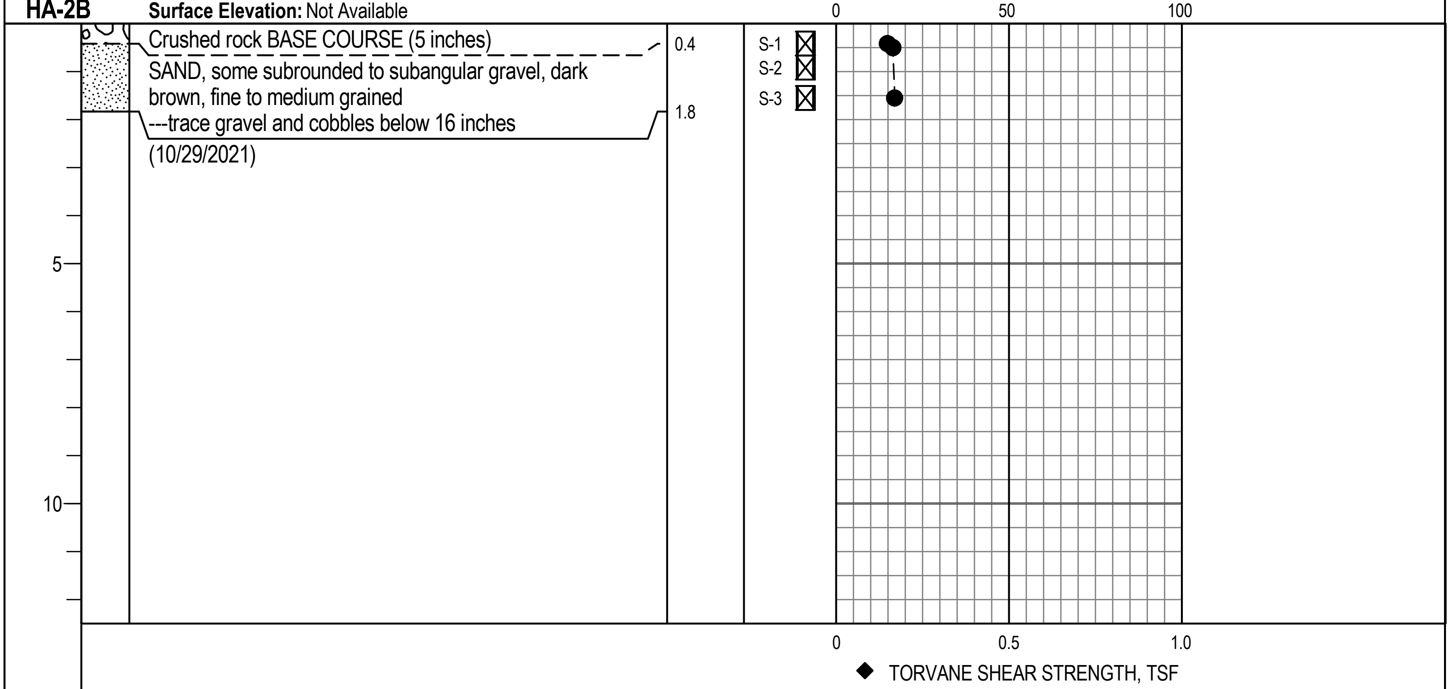
GRI HA LOG (GPS) - 2 PP GRI DATA TEMPLATE.GDT 5/5/22

GRI **BORINGS**

DEPTH, FT	GRAPHIC LOG	CLASSIFICATION OF MATERIAL	ELEVATION, FT / DEPTH, FT	SAMPLE NO.	SAMPLE TYPE	● MOISTURE CONTENT, % □ FINES CONTENT, % LIQUID LIMIT, % PLASTIC LIMIT, % (0 50 100)	COMMENTS AND ADDITIONAL TESTS

HA-2B **Surface Elevation:** Not Available

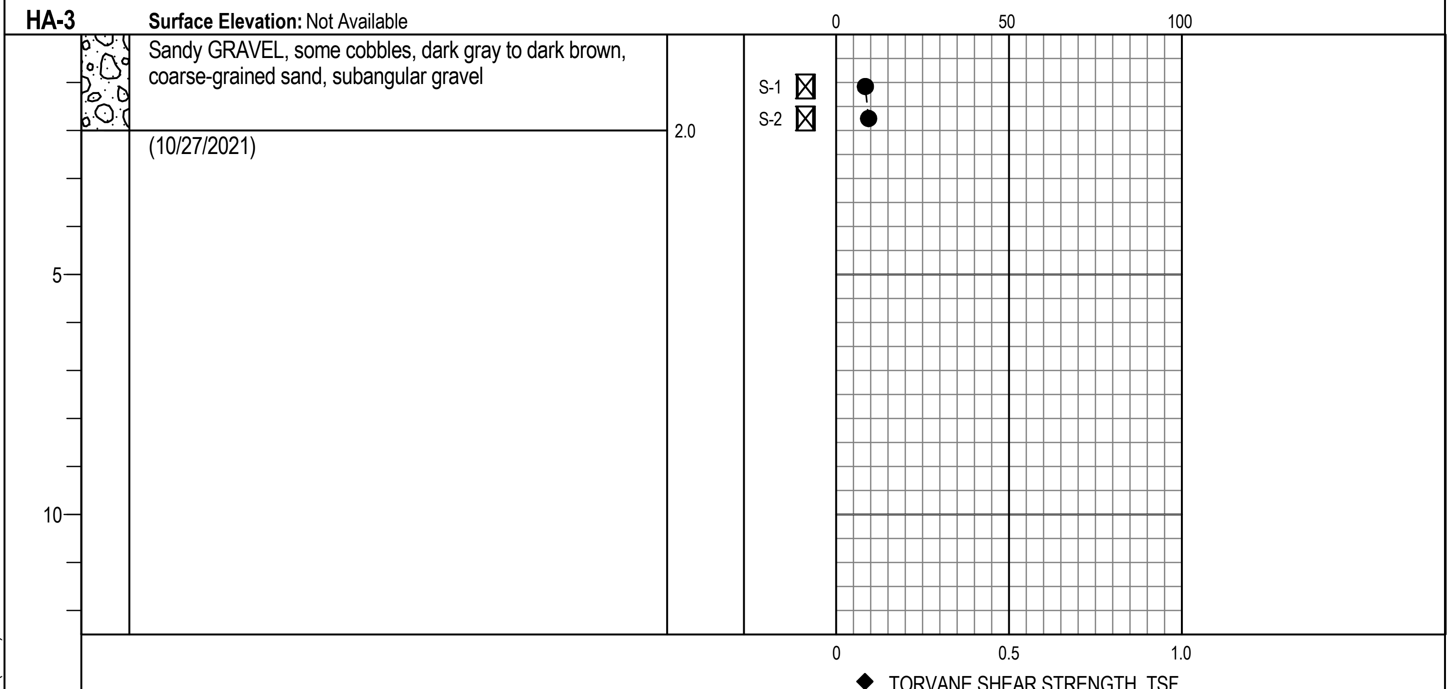
Classification of Material	Depth, FT	Sample No.
Crushed rock BASE COURSE (5 inches)	0.4	S-1
SAND, some subrounded to subangular gravel, dark brown, fine to medium grained ---trace gravel and cobbles below 16 inches	1.8	S-2, S-3
(10/29/2021)		



Logged By: A. Horst **Excavated by:** GRI **Equipment:** Hand Auger
Date Started: 10/29/21 **GPS Coordinates:** 47.8814° N 124.339° W (WGS84) **Note:** See Legend for Explanation of Symbols

HA-3 **Surface Elevation:** Not Available

Classification of Material	Depth, FT	Sample No.
Sandy GRAVEL, some cobbles, dark gray to dark brown, coarse-grained sand, subangular gravel	2.0	S-1, S-2
(10/27/2021)		



Logged By: A. Horst **Excavated by:** GRI **Equipment:** Hand Auger
Date Started: 10/27/21 **GPS Coordinates:** 47.8814° N 124.337° W (WGS84) **Note:** See Legend for Explanation of Symbols

GRI HA LOG (GPS) - 2 PP GRI DATA TEMPLATE.GDT 5/5/22

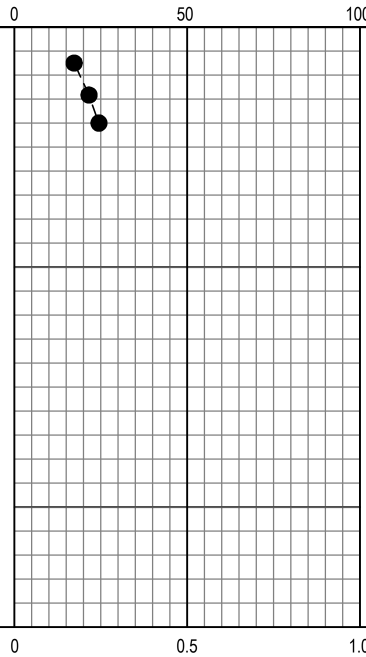
GRI BORINGS

DEPTH, FT	GRAPHIC LOG	CLASSIFICATION OF MATERIAL	ELEVATION, FT / DEPTH, FT	SAMPLE NO.	SAMPLE TYPE	● MOISTURE CONTENT, % □ FINES CONTENT, % ├─┤ LIQUID LIMIT, % PLASTIC LIMIT, % (0 50 100)	COMMENTS AND ADDITIONAL TESTS

HA-4

Surface Elevation: Not Available

Depth	Classification of Material	Elevation/Depth, ft	Sample No.	Sample Type
	SILT, some fine-to medium-grained sand and subrounded gravel and cobbles, dark brown		S-1	☒
			S-2	☒
		2.3	S-3	☒
	(10/27/2021)			
5				
10				



◆ TORVANE SHEAR STRENGTH, TSF

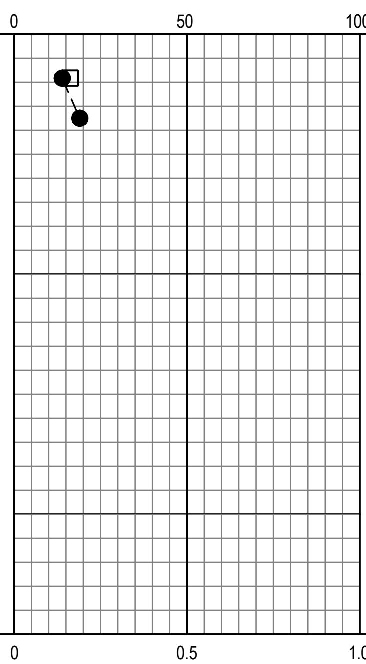
Logged By: A. Horst **Excavated by:** GRI **Equipment:** Hand Auger

Date Started: 10/27/21 **GPS Coordinates:** 47.8822° N 124.336° W (WGS84) **Note:** See Legend for Explanation of Symbols

HA-5

Surface Elevation: Not Available

Depth	Classification of Material	Elevation/Depth, ft	Sample No.	Sample Type
	Silty SAND, some subrounded gravel and cobbles, dark brown, fine to coarse grained		S-1	☒
		2.0	S-2	☒
	(10/27/2021)			
5				
10				



◆ TORVANE SHEAR STRENGTH, TSF

Logged By: A. Horst **Excavated by:** GRI **Equipment:** Hand Auger

Date Started: 10/27/21 **GPS Coordinates:** 47.8833° N 124.335° W (WGS84) **Note:** See Legend for Explanation of Symbols

GRI HA LOG (GPS) - 2 PP GRI DATA TEMPLATE.GDT 5/5/22

GRI

BORINGS

DEPTH, FT	GRAPHIC LOG	CLASSIFICATION OF MATERIAL	ELEVATION, FT / DEPTH, FT	SAMPLE NO.	SAMPLE TYPE	● MOISTURE CONTENT, % / □ FINES CONTENT, % / LIQUID LIMIT, % / PLASTIC LIMIT, % (0 – 50 – 100)	COMMENTS AND ADDITIONAL TESTS

HA-6

Surface Elevation: Not Available

DEPTH, FT	CLASSIFICATION OF MATERIAL	ELEVATION, FT / DEPTH, FT	SAMPLE NO.	SAMPLE TYPE
	Sandy SILT, some subrounded to subangular gravel and cobbles, dark gray to gray, fine-to coarse-grained sand	1.7	S-1 S-2	⊠ ⊠
	(10/27/2021)			
5				
10				

0 – 0.5 – 1.0

◆ TORVANE SHEAR STRENGTH, TSF

Logged By: A. Horst **Excavated by:** GRI **Equipment:** Hand Auger

Date Started: 10/27/21 **GPS Coordinates:** 47.8839° N 124.334° W (WGS84) **Note:** See Legend for Explanation of Symbols

HA-7

Surface Elevation: Not Available

DEPTH, FT	CLASSIFICATION OF MATERIAL	ELEVATION, FT / DEPTH, FT	SAMPLE NO.	SAMPLE TYPE
	SAND, trace silt and subrounded to subangular gravel, dark brown, fine to coarse grained, contains organics		S-1 S-2	⊠ ⊠
	---contains subrounded to subangular cobbles below 18 inches	2.0		
	(10/27/2021)			
5				
10				

0 – 0.5 – 1.0

◆ TORVANE SHEAR STRENGTH, TSF

Logged By: A. Horst **Excavated by:** GRI **Equipment:** Hand Auger

Date Started: 10/27/21 **GPS Coordinates:** 47.8844° N 124.333° W (WGS84) **Note:** See Legend for Explanation of Symbols

GRI HA LOG (GPS) - 2 PP GRI DATA TEMPLATE.GDT 5/5/22

DEPTH, FT	GRAPHIC LOG	CLASSIFICATION OF MATERIAL	ELEVATION, FT / DEPTH, FT	SAMPLE NO. / SAMPLE TYPE	● MOISTURE CONTENT, % □ FINES CONTENT, % LIQUID LIMIT, % PLASTIC LIMIT, % (0 – 50 – 100)	COMMENTS AND ADDITIONAL TESTS

HA-8

Surface Elevation: Not Available

Depth, ft	Classification of Material	Depth, ft	Sample No.
0–2.3	Silty SAND, some subrounded to subangular gravel and cobbles, dark brown, fine to coarse grained, contains debris (Fill)	2.3	S-1, S-2
	(10/28/2021)		

Depth scale: 5, 10

0 – 0.5 – 1.0

◆ TORVANE SHEAR STRENGTH, TSF

Logged By: A. Horst	**Excavated by:** GRI	**Equipment:** Hand Auger
Date Started: 10/28/21	**GPS Coordinates:** 47.8847° N 124.332° W (WGS84)	**Note:** See Legend for Explanation of Symbols

HA-9

Surface Elevation: Not Available

Depth, ft	Classification of Material	Depth, ft	Sample No.
0–2.2	Sandy GRAVEL, some silt, dark brown, fine-to coarse-grained sand, subrounded to subangular gravel ---contains subrounded to subangular cobbles below 20 inches	2.2	S-1, S-2
	(10/27/2021)		

Depth scale: 5, 10

0 – 0.5 – 1.0

◆ TORVANE SHEAR STRENGTH, TSF

Logged By: A. Horst	**Excavated by:** GRI	**Equipment:** Hand Auger
Date Started: 10/27/21	**GPS Coordinates:** 47.8849° N 124.332° W (WGS84)	**Note:** See Legend for Explanation of Symbols

GRI

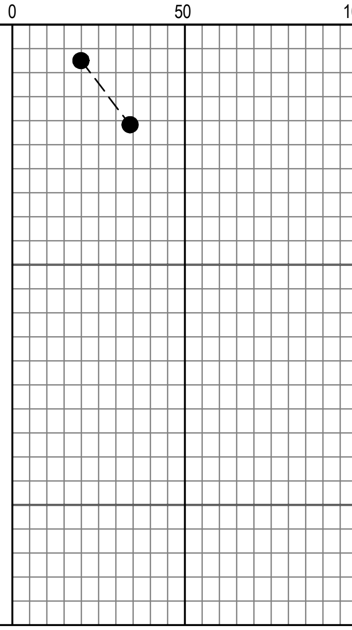
BORINGS

DEPTH, FT	GRAPHIC LOG	CLASSIFICATION OF MATERIAL	ELEVATION, FT / DEPTH, FT	SAMPLE NO. / SAMPLE TYPE	● MOISTURE CONTENT, % ☐ FINES CONTENT, % LIQUID LIMIT, % PLASTIC LIMIT, % (0 – 50 – 100)	COMMENTS AND ADDITIONAL TESTS

HA-10

Surface Elevation: Not Available

DEPTH, FT	CLASSIFICATION OF MATERIAL	ELEVATION, FT / DEPTH, FT	SAMPLE NO.
	Silty SAND, some subrounded to subangular gravel, dark brown, fine to coarse grained		S-1
	Sandy SILT, some subrounded to subangular gravel, dark brown, fine-to coarse-grained sand (10/29/2021)	1.8 / 2.3	S-2
5			
10			



0 0.5 1.0

◆ TORVANE SHEAR STRENGTH, TSF

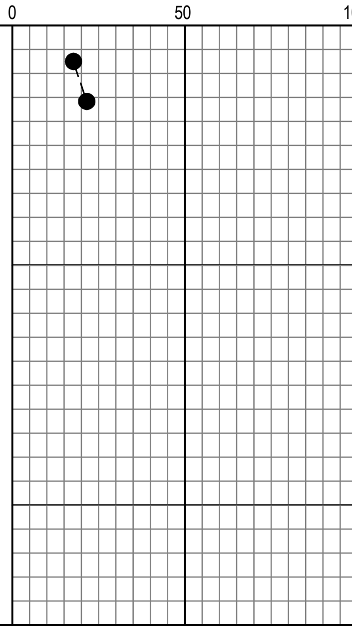
Logged By: A. Horst **Excavated by:** GRI **Equipment:** Hand Auger

Date Started: 10/29/21 **GPS Coordinates:** 47.8847° N 124.332° W (WGS84) **Note:** See Legend for Explanation of Symbols

HA-11

Surface Elevation: Not Available

DEPTH, FT	CLASSIFICATION OF MATERIAL	ELEVATION, FT / DEPTH, FT	SAMPLE NO.
	Sandy SILT, some subrounded to subangular gravel, gray to green-gray, fine-to coarse-grained sand		S-1
	Silty SAND, some subrounded to subangular gravel, green-gray, fine to coarse grained (10/29/2021)	1.3 / 1.8	S-2
5			
10			



0 0.5 1.0

◆ TORVANE SHEAR STRENGTH, TSF

Logged By: A. Horst **Excavated by:** GRI **Equipment:** Hand Auger

Date Started: 10/29/21 **GPS Coordinates:** 47.8844° N 124.331° W (WGS84) **Note:** See Legend for Explanation of Symbols

GRI HA LOG (GPS) - 2 PP GRI DATA TEMPLATE.GDT 5/5/22

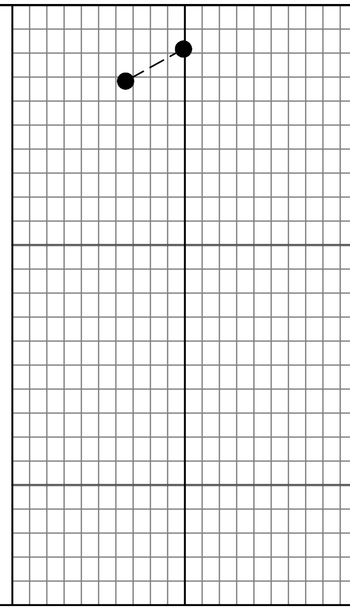
GRI **BORINGS**

DEPTH, FT	GRAPHIC LOG	CLASSIFICATION OF MATERIAL	ELEVATION, FT / DEPTH, FT	SAMPLE NO.	SAMPLE TYPE	● MOISTURE CONTENT, % ☐ FINES CONTENT, % LIQUID LIMIT, % PLASTIC LIMIT, % (0 50 100)	COMMENTS AND ADDITIONAL TESTS

HA-12

Surface Elevation: Not Available

DEPTH, FT	CLASSIFICATION OF MATERIAL	ELEVATION, FT / DEPTH, FT	SAMPLE NO.	COMMENTS AND ADDITIONAL TESTS
0–1.8	SILT, trace fine-grained sand and subrounded gravel and cobbles, dark brown, contains trace organics	1.8	S-1, S-2	Organics are generally comprised of fine roots and occasional, scattered roots up to 1/4 inch thick and bark chips. The existing corduroy was not encountered.
	(10/29/2021)			



◆ TORVANE SHEAR STRENGTH, TSF

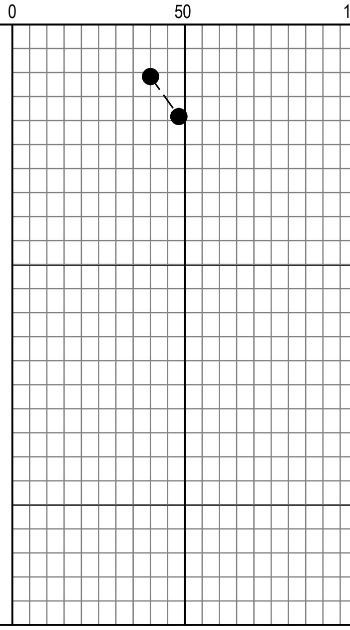
Logged By: A. Horst | **Excavated by:** GRI | **Equipment:** Hand Auger

Date Started: 10/29/21 | **GPS Coordinates:** 47.8769° N 124.314° W (WGS84) | **Note:** See Legend for Explanation of Symbols

HA-13

Surface Elevation: Not Available

DEPTH, FT	CLASSIFICATION OF MATERIAL	ELEVATION, FT / DEPTH, FT	SAMPLE NO.	COMMENTS AND ADDITIONAL TESTS
0–2.2	SILT, some subrounded to subangular gravel, trace fine-to coarse-grained sand, dark brown, contains trace organics	2.2	S-1, S-2	Organics are generally comprised of fine roots and occasional, scattered bark chips. The existing corduroy was not encountered.
	(10/29/2021)			



◆ TORVANE SHEAR STRENGTH, TSF

Logged By: A. Horst | **Excavated by:** GRI | **Equipment:** Hand Auger

Date Started: 10/29/21 | **GPS Coordinates:** 47.8765° N 124.314° W (WGS84) | **Note:** See Legend for Explanation of Symbols

GRI

BORINGS

KESSLER DYNAMIC CONE PENETROMETER LOG

JOB NO.: W1285 TO2 DRAWN BY: LAH TESTING DATE: 10/27/2021

Test Number	KDCP-1	Surface Type	Gravel/Soil
Location	Undi Road, Forks, WA	Hammer	17.6 pounds

Depth, inches	Depth, millimeters	Cumulative Blows	Slope
0.0	0	0	---
3.8	96	2	0.02
5.8	148	4	0.04
8.1	207	8	0.07
10.2	259	12	0.08
12.4	314	18	0.11
14.0	356	66	1.14
16.4	416	136	1.17
18.5	470	144	0.15
21.3	540	162	0.26
23.6	599	192	0.51
25.4	646	220	0.60
27.6	701	240	0.36
29.4	748	270	0.64
31.7	806	288	0.31
32.5	826	300	0.60
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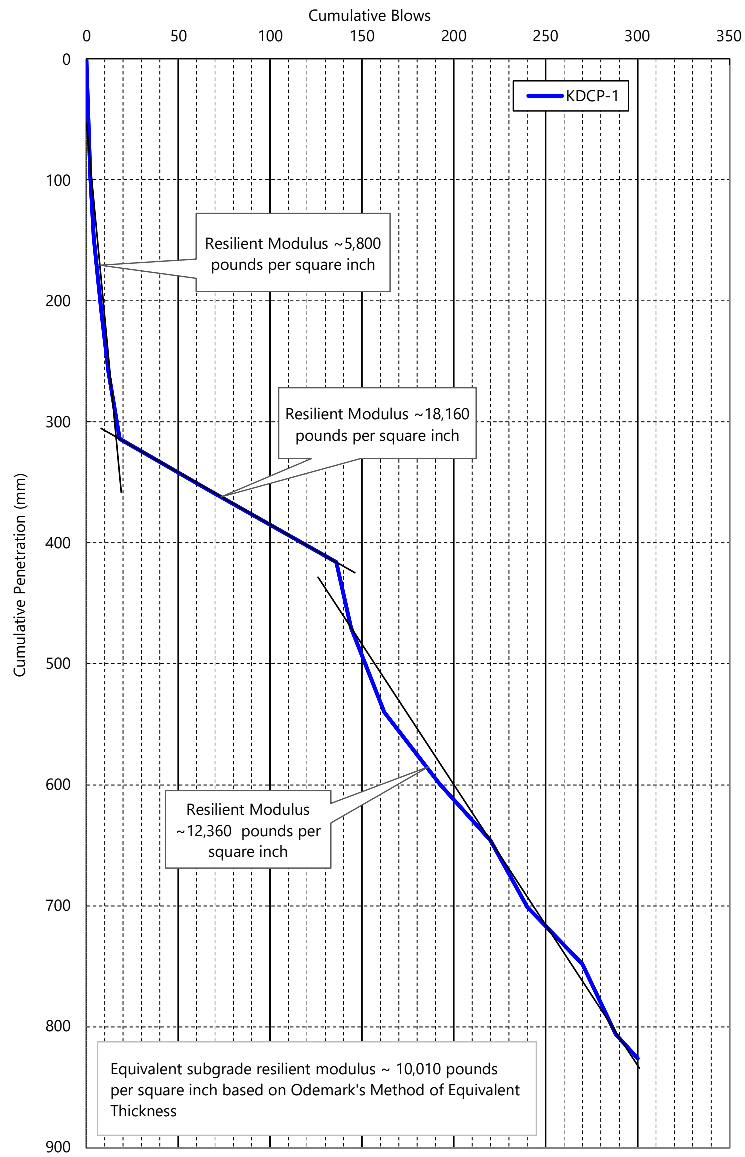

GRI

DYNAMIC CONE PENETROMETER

MAY 2022 JOB NO.W1285-TO2 FIG. 10A

KESSLER DYNAMIC CONE PENETROMETER LOG

JOB NO.: W1285 TO2 | DRAWN BY: LAH | TESTING DATE: 10/27/2021

Test Number	KDCP-2	Surface Type	Gravel/Soil
Location	Undi Road, Forks, WA	Hammer	17.6 pounds

Depth, inches	Depth, millimeters	Cumulative Blows	Slope
0.0	0	0	---
1.6	40	3	0.08
3.2	81	10	0.17
4.6	117	14	0.11
6.1	155	19	0.13
8.2	208	46	0.51
9.6	244	52	0.17
11.8	299	61	0.16
15.4	392	72	0.12
18.4	467	77	0.07
20.7	525	81	0.07
23.1	586	86	0.08
27.0	685	91	0.05
30.3	769	93	0.02
32.0	813	94	0.02
33.6	853	95	0.03
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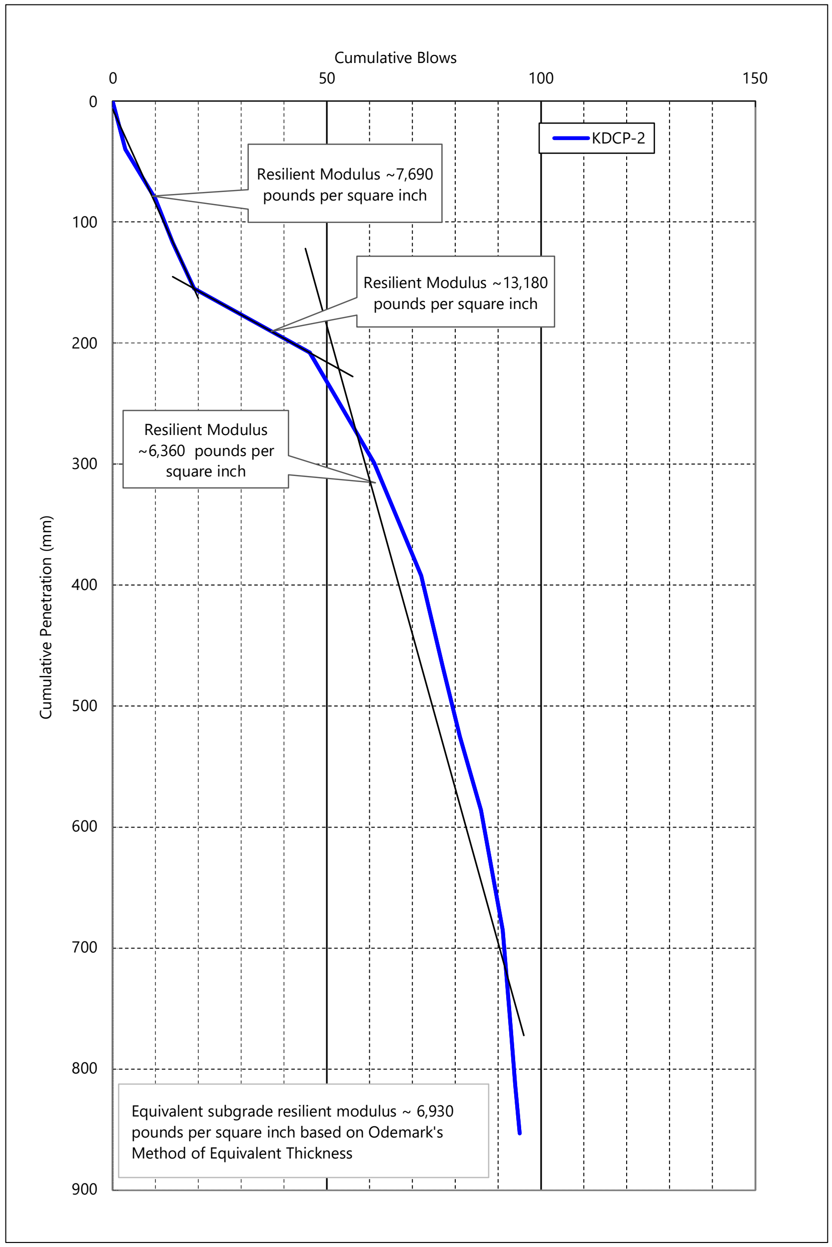

GRI

DYNAMIC CONE PENETROMETER

MAY 2022 | JOB NO.W1285-TO2 | FIG. 11A

KESSLER DYNAMIC CONE PENETROMETER LOG

JOB NO.:	W1285 TO2	DRAWN BY: LAH	TESTING DATE:	10/27/2021

Test Number	KDCP-3	Surface Type	Gravel/Soil
Location	Undi Road, Forks, WA	Hammer	17.6 pounds

Depth, inches	Depth, millimeters	Cumulative Blows	Slope
0.0	0	0	---
1.7	44	4	0.09
3.0	75	9	0.16
5.0	128	24	0.28
7.0	177	54	0.61
8.8	223	84	0.65
10.5	266	104	0.47
12.5	318	131	0.52
14.2	361	186	1.28
15.5	393	226	1.25
15.9	403	238	1.20
16.1	410	252	2.00
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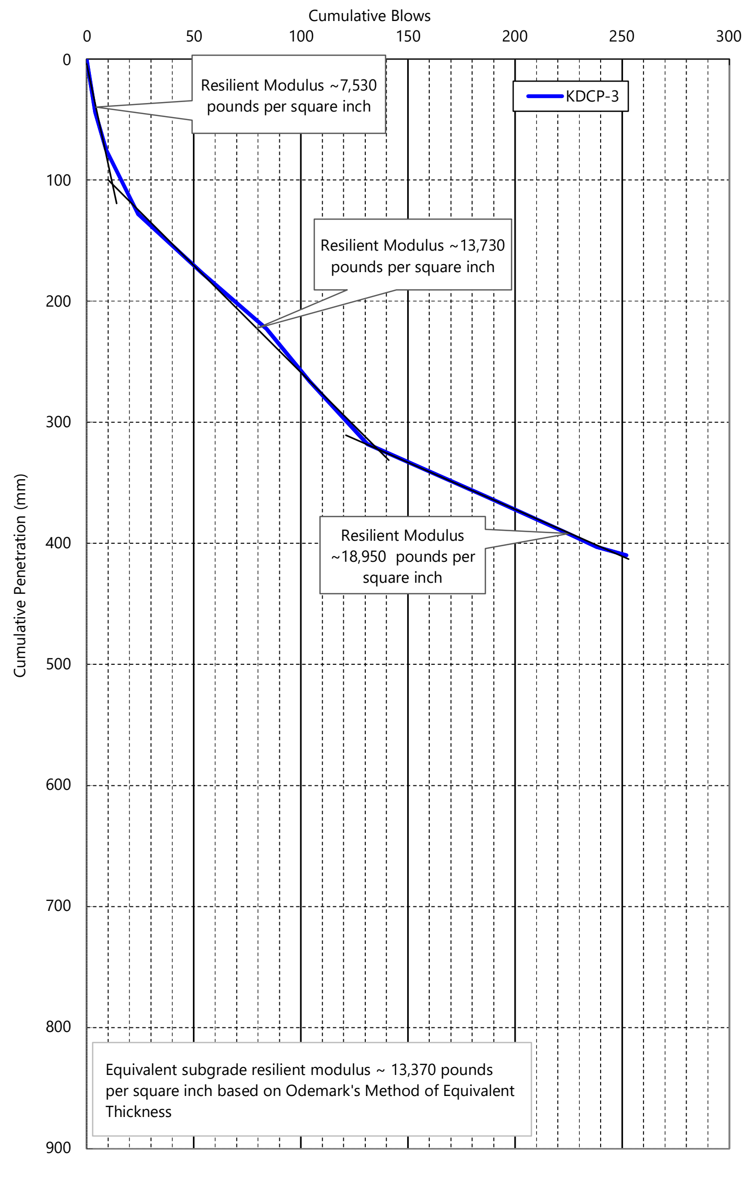

GRI

DYNAMIC CONE PENETROMETER

MAY 2022 JOB NO.W1285-TO2 FIG. 12A

KESSLER DYNAMIC CONE PENETROMETER LOG

JOB NO.: W1285 TO2 DRAWN BY: LAH TESTING DATE: 10/27/2021

Test Number	KDCP-4	Surface Type	Gravel/Soil
Location	Undi Road, Forks, WA	Hammer	17.6 pounds

Depth, inches	Depth, millimeters	Cumulative Blows	Slope
0.0	0	0	---
2.0	52	1	0.02
3.5	90	3	0.05
5.7	145	6	0.05
7.9	201	10	0.07
9.6	244	13	0.07
11.6	295	17	0.08
13.4	341	20	0.07
15.6	395	33	0.24
17.3	440	44	0.24
20.2	512	51	0.10
23.8	604	56	0.05
25.6	649	59	0.07
27.1	688	63	0.10
29.2	741	66	0.06
31.7	804	69	0.05
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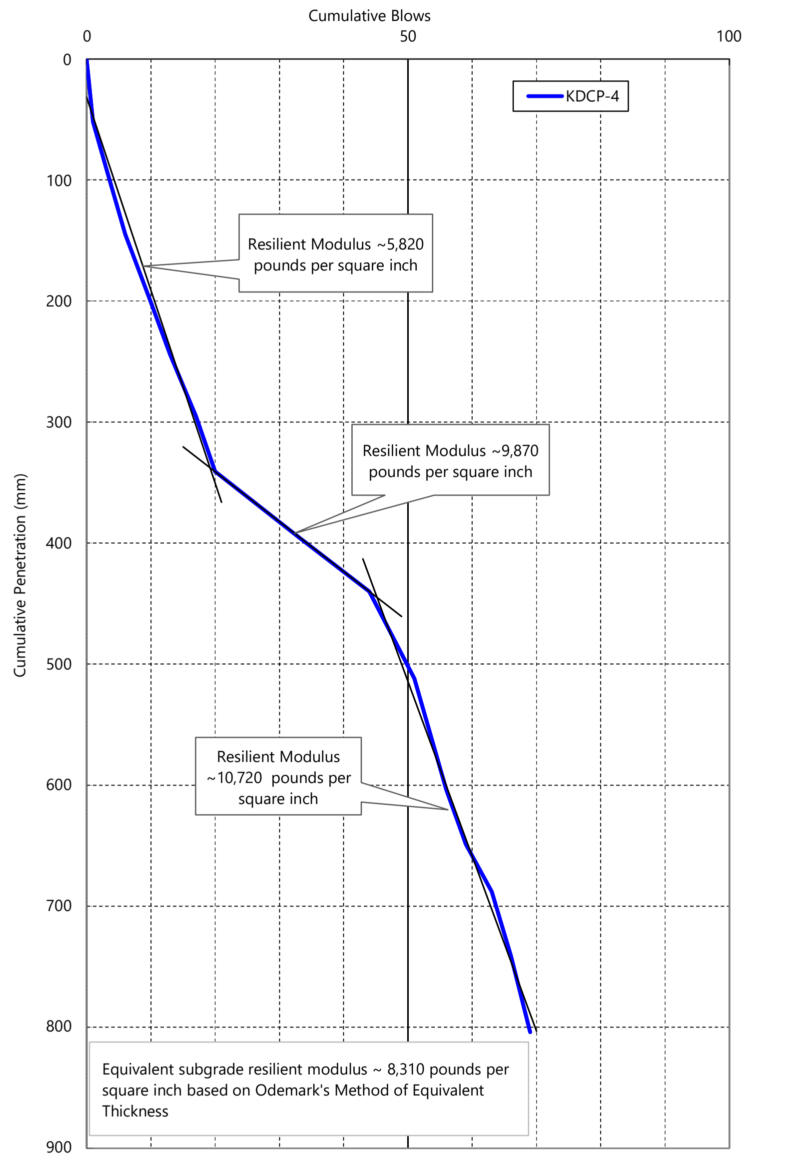

GRI

DYNAMIC CONE PENETROMETER

MAY 2022 JOB NO.W1285-TO2 FIG. 13A

KESSLER DYNAMIC CONE PENETROMETER LOG

JOB NO.: W1285 TO2 | DRAWN BY: LAH | TESTING DATE: 10/27/2021

Test Number	KDCP-5	Surface Type	Gravel/Soil
Location	Undi Road, Forks, WA	Hammer	17.6 pounds

Depth, inches	Depth, millimeters	Cumulative Blows	Slope
0.0	0	0	---
2.2	55	2	0.04
4.1	103	5	0.06
6.3	159	9	0.07
8.3	211	17	0.15
9.9	251	20	0.08
12.6	319	25	0.07
15.4	392	28	0.04
18.9	480	30	0.02
21.0	533	33	0.06
23.8	605	37	0.06
25.6	649	42	0.11
27.3	694	45	0.07
30.1	765	48	0.04
33.0	839	51	0.04
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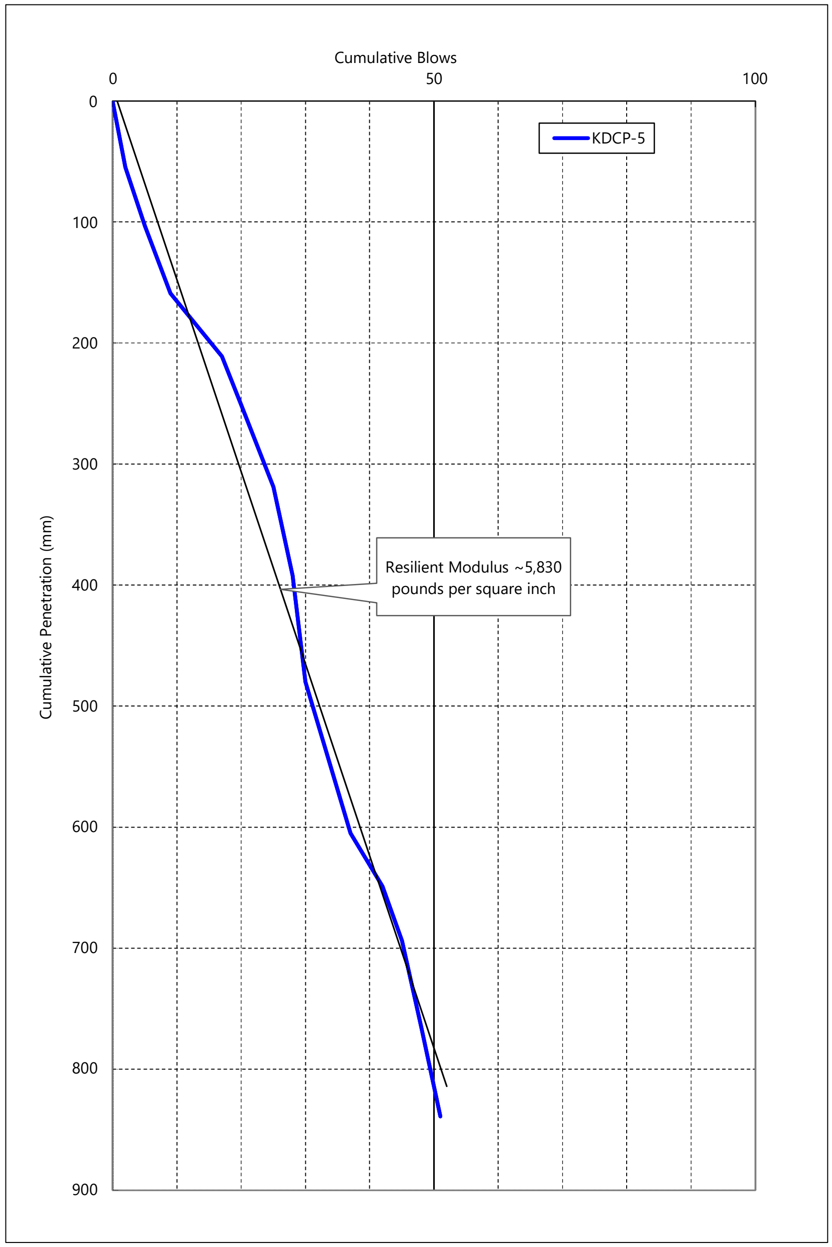

KESSLER DYNAMIC CONE PENETROMETER LOG

JOB NO.:	W1285 TO2	DRAWN BY: LAH	TESTING DATE:	10/27/2021

Test Number	KDCP-6	Surface Type	Gravel/Soil
Location	Undi Road, Forks, WA	Hammer	17.6 pounds

Depth, inches	Depth, millimeters	Cumulative Blows	Slope
0.0	0	0	---
1.9	48	2	0.04
4.1	104	5	0.05
6.5	166	7	0.03
8.8	224	11	0.07
10.6	270	14	0.07
12.0	304	18	0.12
13.9	353	23	0.10
15.1	383	33	0.33
15.4	391	43	1.25
15.7	398	64	3.00
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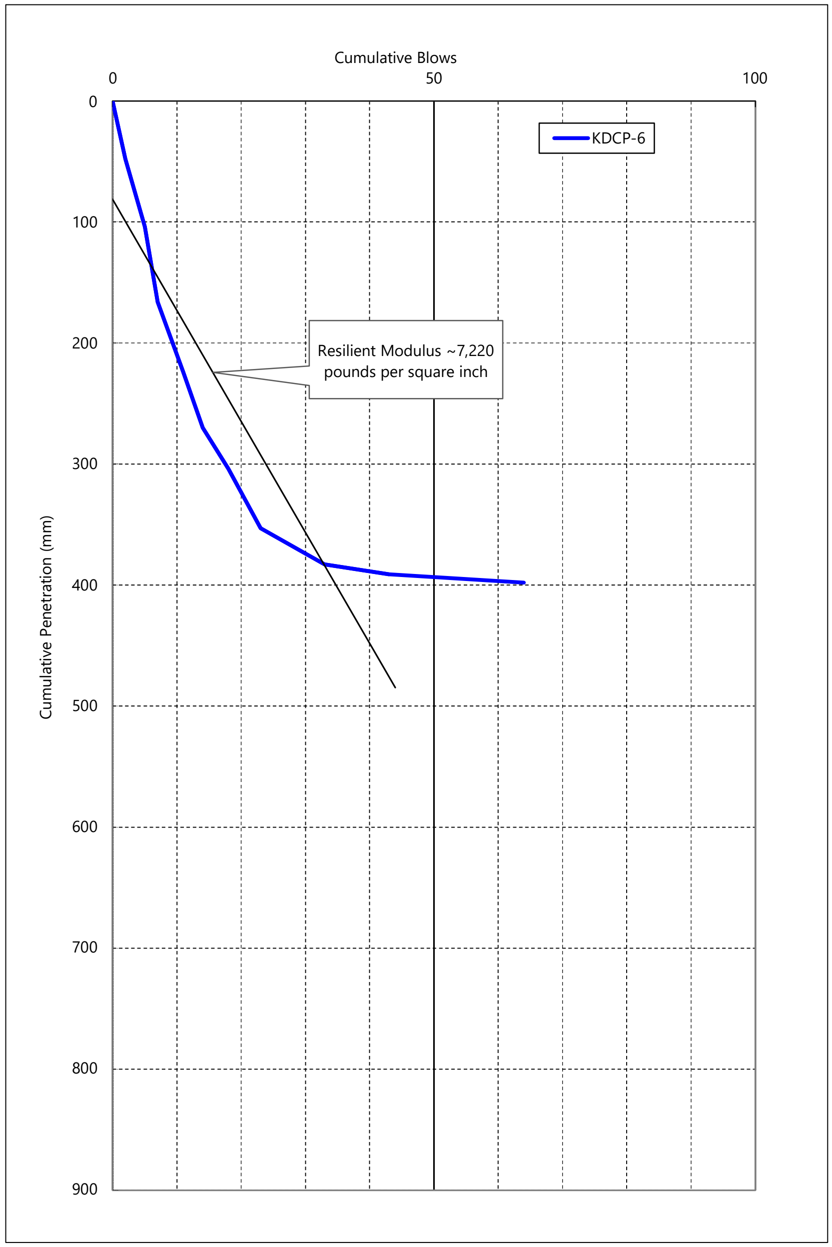

GRI

DYNAMIC CONE PENETROMETER

MAY 2022 JOB NO.W1285-TO2 FIG. 15A

KESSLER DYNAMIC CONE PENETROMETER LOG

JOB NO.:	W1285 TO2	DRAWN BY: LAH	TESTING DATE:	10/27/2021

Test Number	KDCP-7	Surface Type	Gravel/Soil
Location	Undi Road, Forks, WA	Hammer	17.6 pounds

Depth, inches	Depth, millimeters	Cumulative Blows	Slope
0.0	0	0	---
1.7	44	1	0.02
3.7	95	4	0.06
4.6	116	14	0.48
6.3	159	21	0.16
8.1	205	26	0.11
10.4	264	33	0.12
11.9	302	41	0.21
14.3	362	49	0.13
16.7	425	61	0.19
18.9	479	70	0.17
20.6	523	80	0.23
22.8	579	90	0.18
24.7	628	97	0.14
26.9	684	106	0.16
28.7	729	118	0.27
29.6	751	128	0.45
31.3	795	143	0.34
32.6	828	153	0.30
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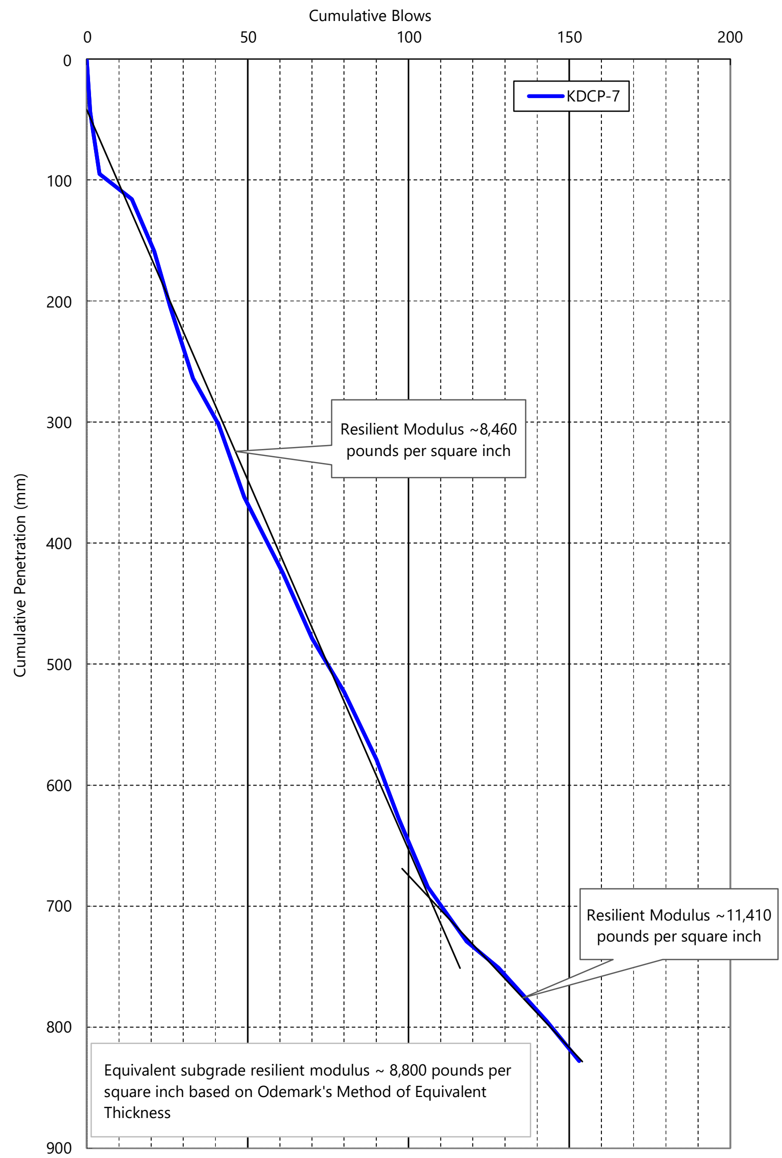

GRI

DYNAMIC CONE PENETROMETER

KESSLER DYNAMIC CONE PENETROMETER LOG

JOB NO.: W1285 TO2 | DRAWN BY: LAH | TESTING DATE: 10/27/2021

Test Number	KDCP-8	Surface Type	Gravel/Soil
Location	Undi Road, Forks, WA	Hammer	17.6 pounds

Depth, inches	Depth, millimeters	Cumulative Blows	Slope
---	---	0	---
6.3	160	1	---
7.8	199	2	0.03
10.0	254	3	0.02
12.7	323	5	0.03
15.3	389	7	0.03
18.5	469	9	0.03
23.0	583	11	0.02
23.9	608	13	0.08
26.7	679	15	0.03
29.4	748	16	0.01
30.9	786	18	0.05
32.4	822	21	0.08
35.6	903	25	0.05
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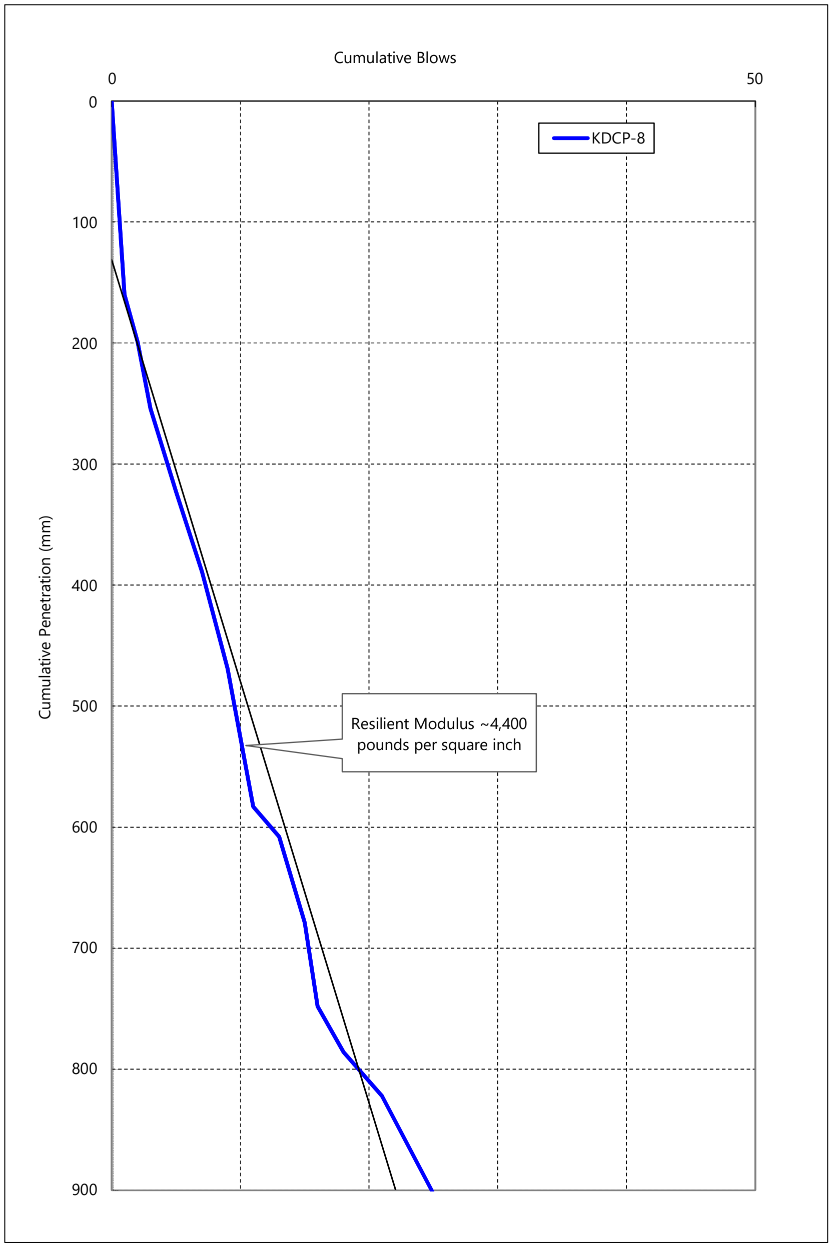

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DYNAMIC CONE PENETROMETER

MAY 2022 JOB NO.W1285-TO2 FIG. 17A

KESSLER DYNAMIC CONE PENETROMETER LOG

JOB NO.: W1285 TO2 DRAWN BY: LAH TESTING DATE: 10/27/2021

Test Number	KDCP-9	Surface Type	Gravel/Soil
Location	Undi Road, Forks, WA	Hammer	17.6 pounds

Depth, inches	Depth, millimeters	Cumulative Blows	Slope
0.0	0	0	---
2.1	54	2	0.04
3.6	91	7	0.14
5.5	140	13	0.12
7.3	185	21	0.18
9.5	242	28	0.12
12.5	318	33	0.07
14.4	365	34	0.02
16.9	428	35	0.02
19.3	490	40	0.08
20.4	519	45	0.17
21.0	534	51	0.40
23.0	585	66	0.29
25.1	638	83	0.32
26.8	681	103	0.47
28.6	727	123	0.43
30.9	784	143	0.35
32.2	817	152	0.27
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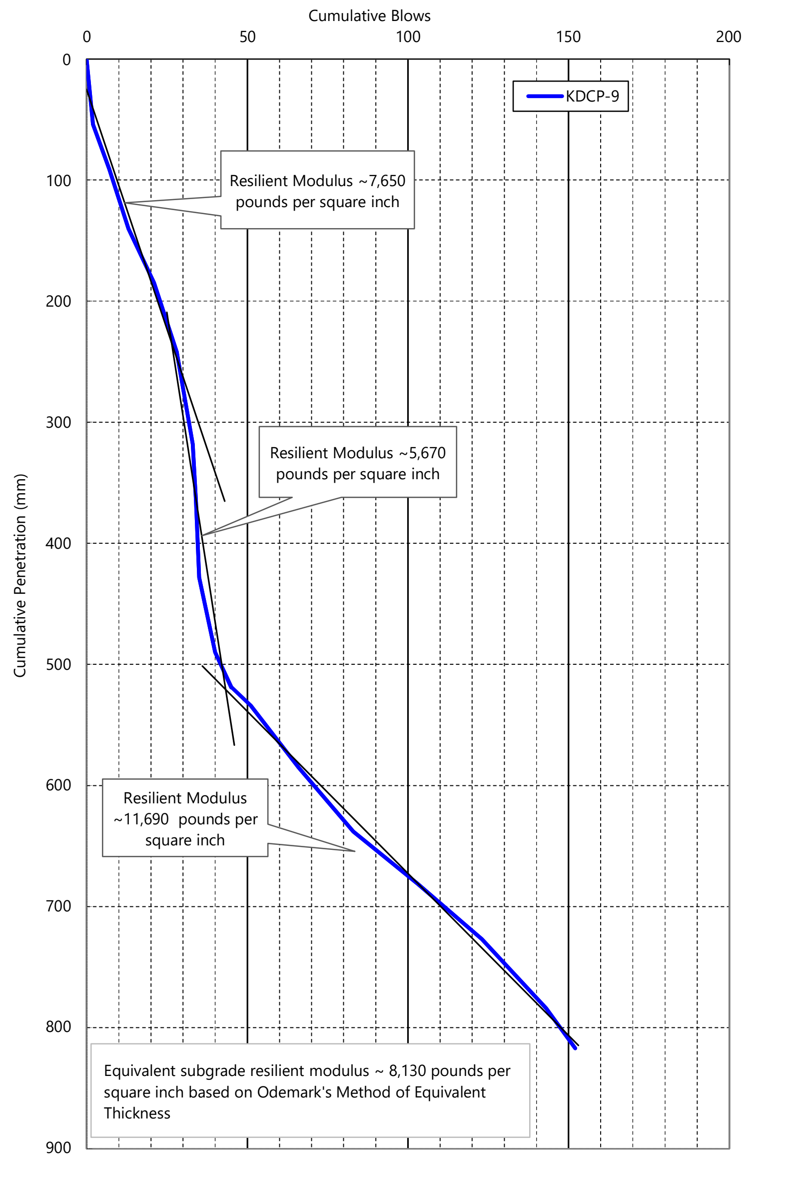

GRI

DYNAMIC CONE PENETROMETER

MAY 2022 JOB NO.W1285-TO2 FIG. 18A

KESSLER DYNAMIC CONE PENETROMETER LOG

JOB NO.: W1285 TO2 | DRAWN BY: LAH | TESTING DATE: 10/27/2021

Test Number	KDCP-10	Surface Type	Gravel/Soil
Location	Undi Road, Forks, WA	Hammer	17.6 pounds

Depth, inches	Depth, millimeters	Cumulative Blows	Slope
0.0	0	0	---
3.5	90	1	0.01
5.4	137	3	0.04
7.6	192	5	0.04
9.4	238	7	0.04
11.4	290	9	0.04
13.1	334	10	0.02
14.8	376	11	0.02
18.8	477	13	0.02
21.3	542	14	0.02
23.1	587	22	0.18
25.1	637	31	0.18
26.9	684	36	0.11
29.0	737	40	0.08
31.5	799	45	0.08
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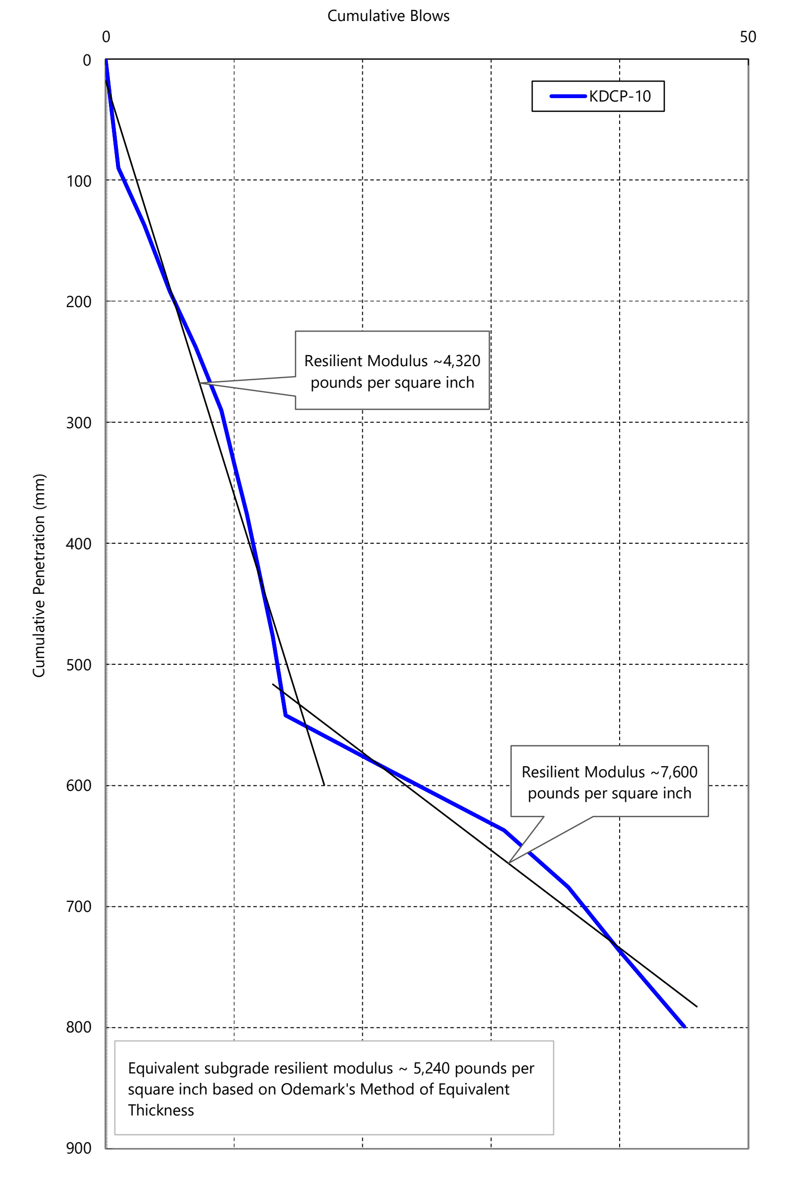

GRI

DYNAMIC CONE PENETROMETER

MAY 2022 | JOB NO.W1285-TO2 | FIG. 19A

KESSLER DYNAMIC CONE PENETROMETER LOG

JOB NO.: W1285 TO2 | DRAWN BY: LAH | TESTING DATE: 10/27/2021

Test Number	KDCP-11	Surface Type	Gravel/Soil
Location	Undi Road, Forks, WA	Hammer	17.6 pounds

Depth, inches	Depth, millimeters	Cumulative Blows	Slope
0.0	0	0	---
1.7	44	2	0.05
3.3	83	12	0.26
5.3	135	24	0.23
7.2	183	37	0.27
9.3	236	51	0.26
11.1	281	58	0.16
13.5	344	62	0.06
15.5	394	65	0.06
17.3	440	68	0.07
19.9	505	70	0.03
21.5	547	72	0.05
23.5	598	75	0.06
25.4	644	77	0.04
27.5	698	80	0.06
29.3	744	84	0.09
31.5	799	88	0.07
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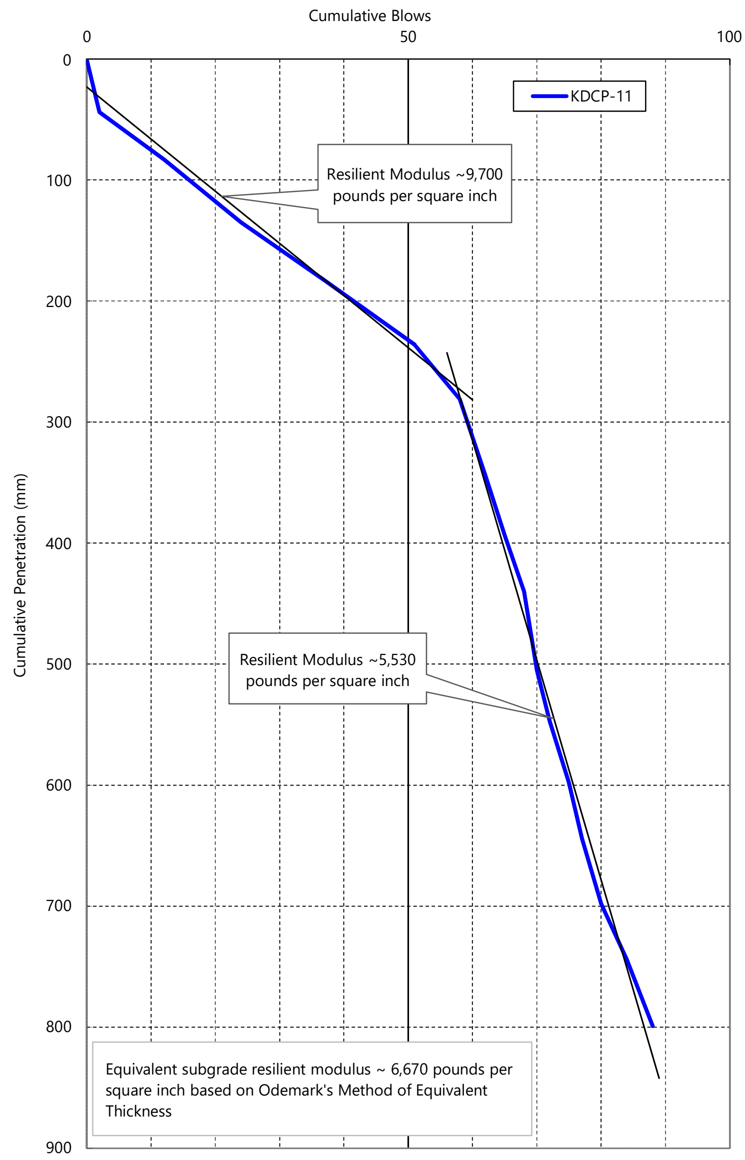

GRI

DYNAMIC CONE PENETROMETER

MAY 2022 | JOB NO.W1285-TO2 | FIG. 20A

KESSLER DYNAMIC CONE PENETROMETER LOG

JOB NO.: W1285 TO2 | DRAWN BY: LAH | TESTING DATE: 10/27/2021

Test Number	KDCP-12	Surface Type	Gravel/Soil
Location	Undi Road, Forks, WA	Hammer	17.6 pounds

Depth, inches	Depth, millimeters	Cumulative Blows	Slope
0.0	0	0	---
3.7	94	3	0.03
7.4	188	5	0.02
9.3	235	7	0.04
10.5	267	8	0.03
12.5	317	10	0.04
14.4	365	14	0.08
16.7	423	17	0.05
18.9	479	19	0.04
20.4	518	23	0.10
22.4	569	28	0.10
26.5	674	31	0.03
28.3	719	33	0.04
30.4	773	36	0.06
32.7	831	40	0.07
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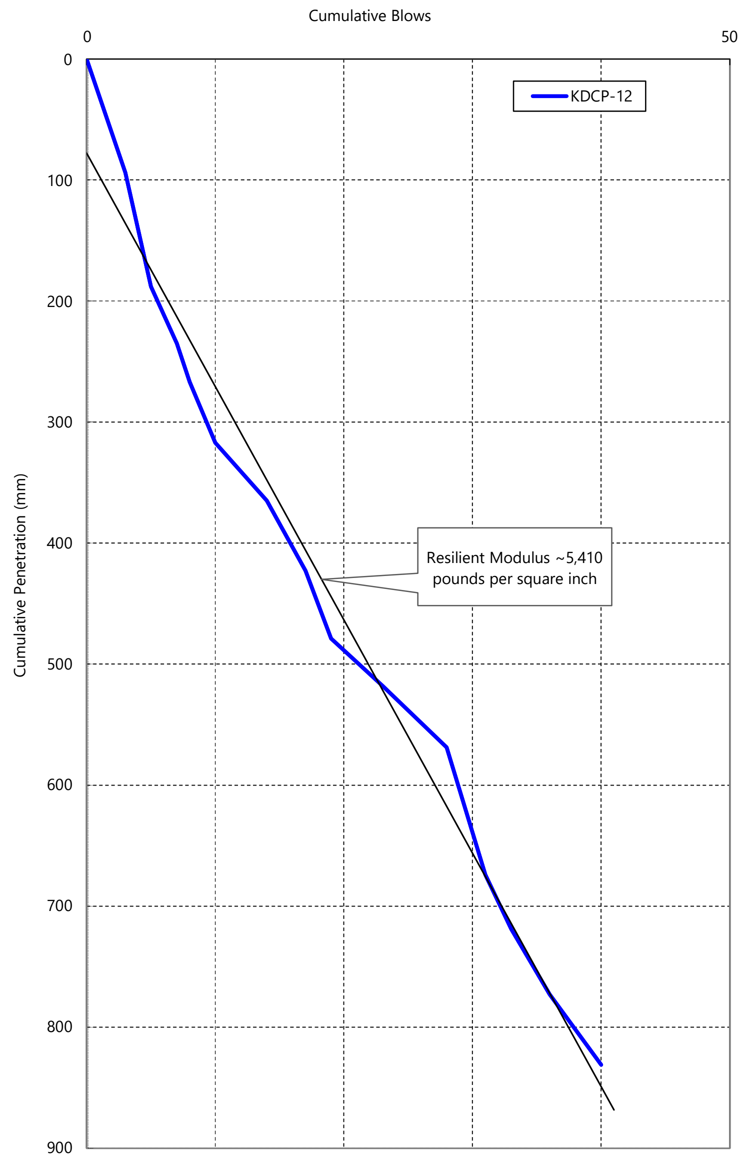

GRI

DYNAMIC CONE PENETROMETER

MAY 2022 | JOB NO.W1285-TO2 | FIG. 21A

KESSLER DYNAMIC CONE PENETROMETER LOG

JOB NO.: W1285 TO2 DRAWN BY: LAH TESTING DATE: 10/27/2021

Test Number	KDCP-13	Surface Type	Gravel/Soil
Location	Undi Road, Forks, WA	Hammer	17.6 pounds

Depth, inches	Depth, millimeters	Cumulative Blows	Slope
0.0	0	0	---
4.1	103	1	0.01
5.6	142	2	0.03
7.3	185	5	0.07
10.0	255	11	0.09
11.2	284	12	0.03
12.9	328	13	0.02
16.2	412	15	0.02
17.7	450	16	0.03
19.2	487	17	0.03
22.0	560	19	0.03
24.7	627	21	0.03
27.2	691	23	0.03
29.8	756	25	0.03
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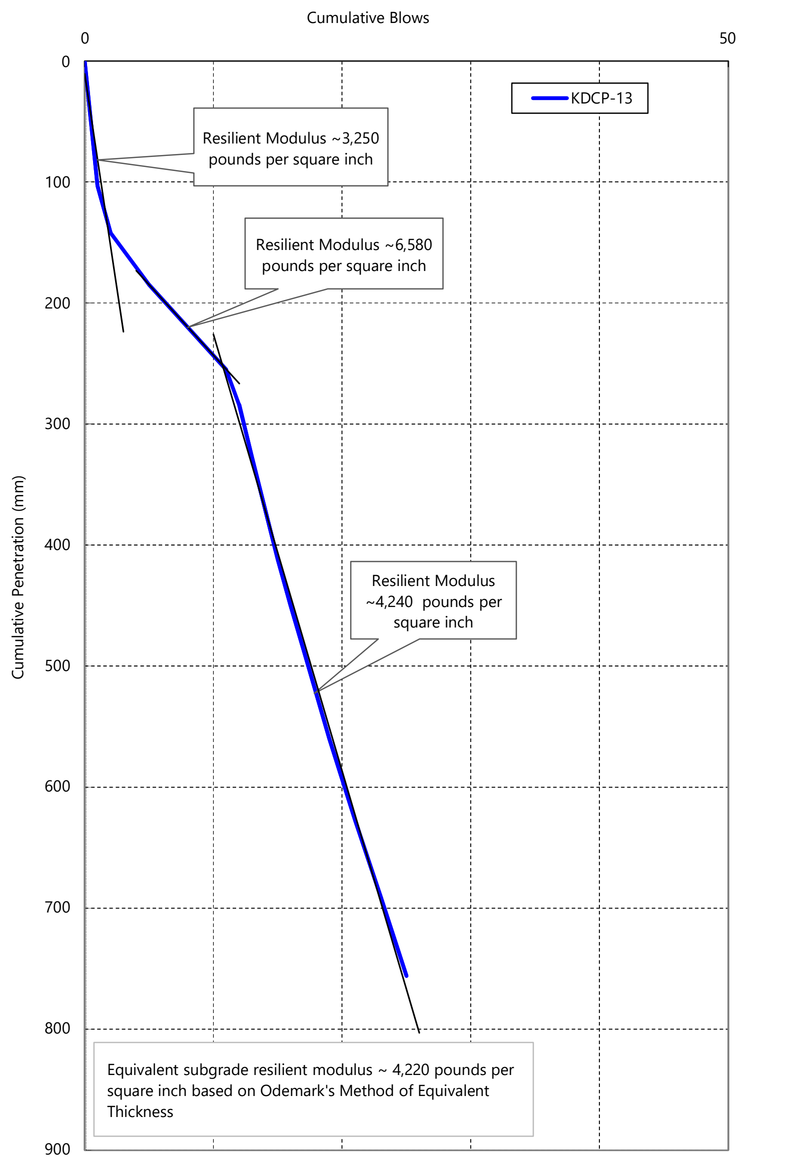
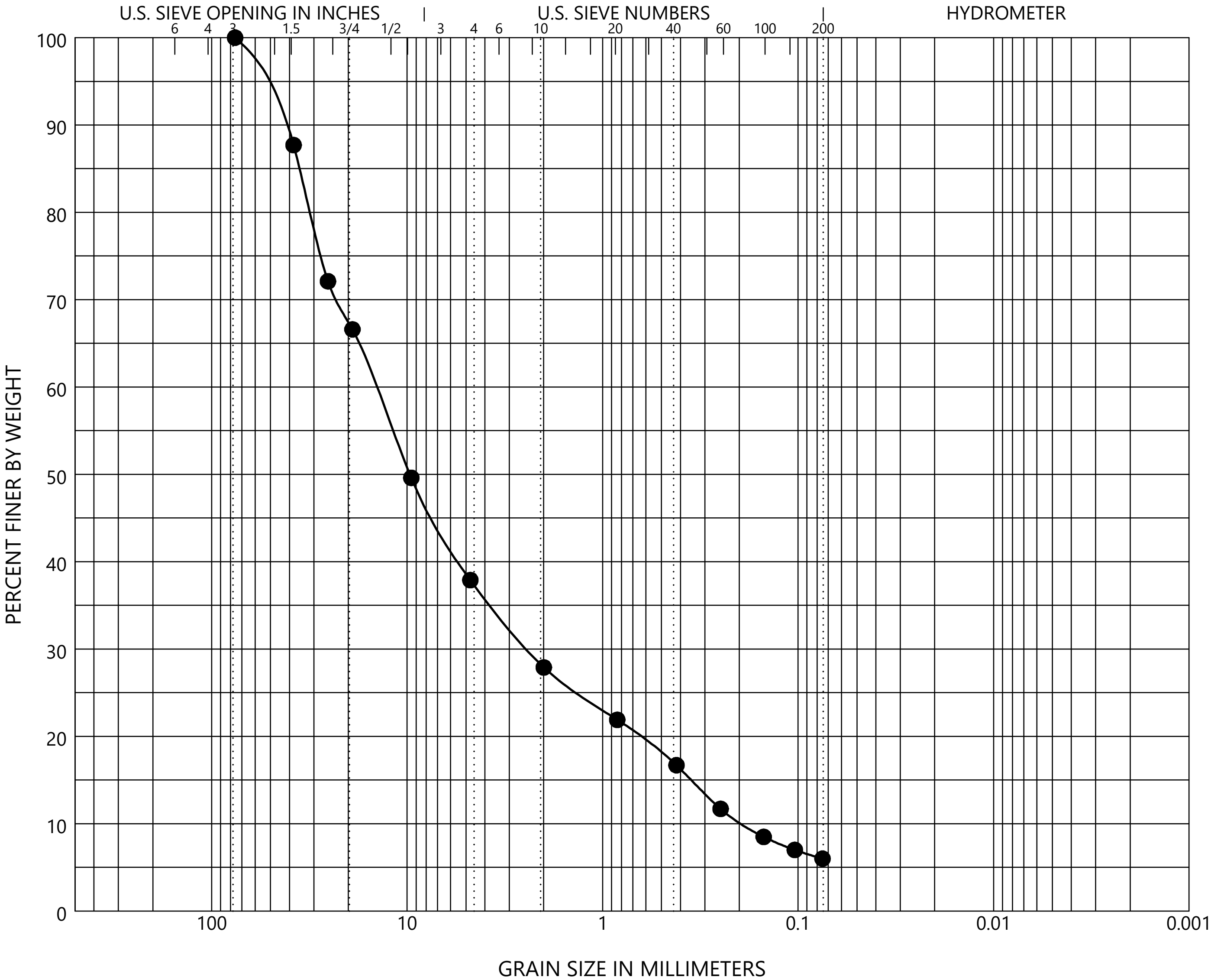


GRI

DYNAMIC CONE PENETROMETER

MAY 2022 JOB NO.W1285-TO2 FIG. 22A



COBBLES	GRAVEL		SAND			SILT OR CLAY
	Coarse	Fine	Coarse	Medium	Fine	

	Location	Sample	Depth, ft	Classification	Gravel, %	Sand, %	Fines, %
●	TP-3	S-1	2.0	Sandy GRAVEL, some silt, rounded gravel, fine-to coarse-grained sand	61.9	31.9	6.0

GRAIN SIZE GRI - 1 PER PAGE GRI DATA TEMPLATE.GDT 5/4/22

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GRAIN SIZE DISTRIBUTION

MAY 2022 JOB NO. W1285-TO2 FIG. 23A

APPENDIX B

Pavement Design Calculations

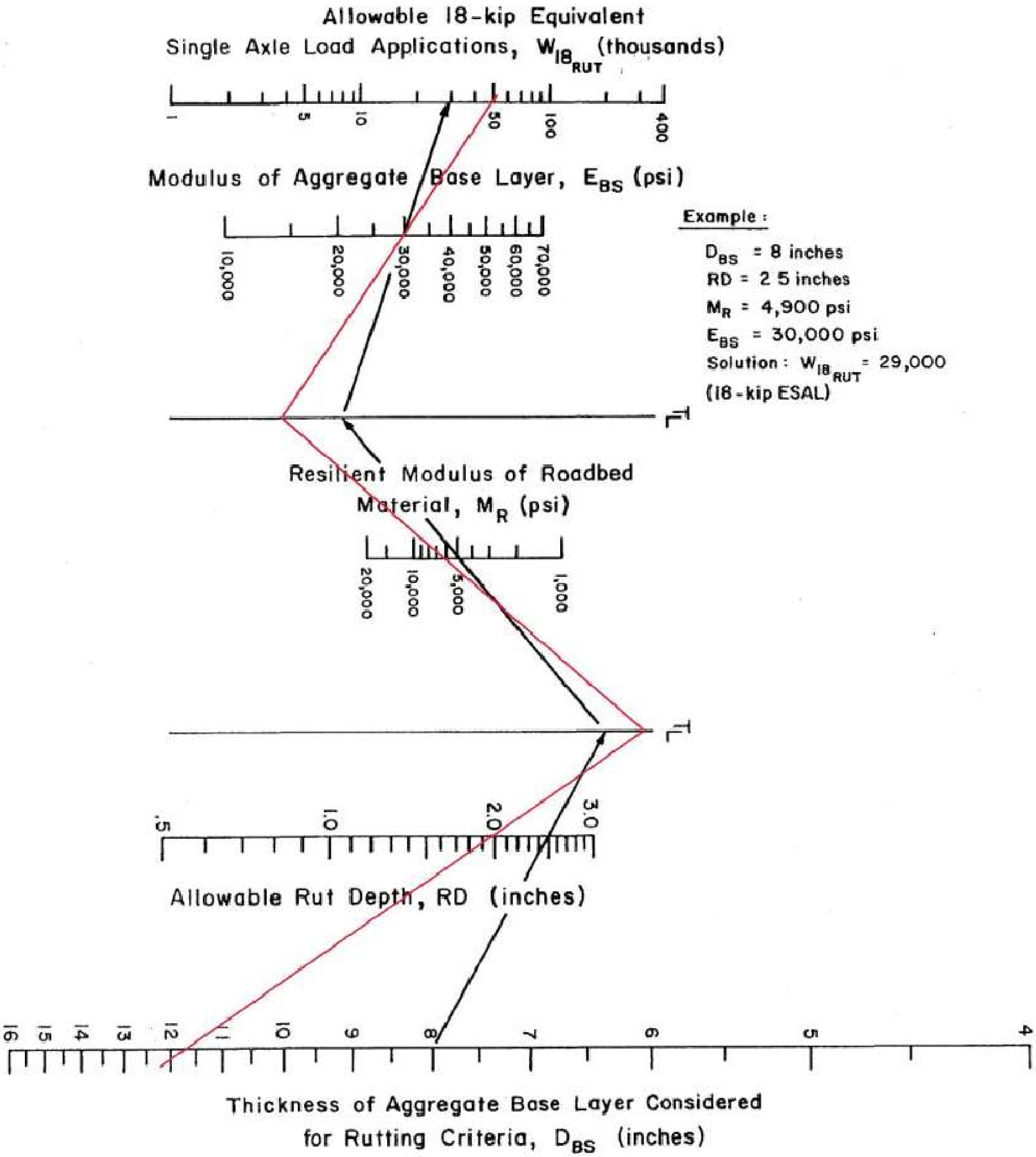

Figure 4.3. Design Chart for Aggregate-Surfaced Roads Considering Allowable Rutting

—— Design Calculations

Note(s): Aggregate base modulus value based on Washington Department of Transportation Pavement Design Policy

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AGGREGATE THICKNESS DESIGN

MAY 2022 JOB NO. W1285-TO2 FIG. 1B